Lake Roosevelt Rainbow Trout

Habitat/Passage Improvement Project

FINAL REPORT PHASE I

August 1990 - December 1991

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Kettle Falls. Prior to Construction of Grand Coulee Dam.

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ABSTRACT

Lake Roosevelt Rainbow Trout Habitat/Passage Improvement Project

The goal of the project is to protect and enhance the adfluvial rainbow trout of Lake Roosevelt that utilize tributary streams for spawning and rearing, The collection of the base line data will aid in the determination of the contribution of adfluvial rainbow trout to the Lake Roosevelt fishery. It is anticipated that areas suitable for habitat improvement will be identified. Streams with restorable habitats will be selected for improvements. Completion of improvement efforts should increase the contribution of adfluvial rainbow trout to the resident fishery in Lake Roosevelt.

The initial phase of this project (Phase I, baseline data collection) was directed at the assessment of limiting factors such as quality and quantity of available spawning gravel, identification of passage barriers, and assessment of other limiting factors. Population estimates were conducted using the Seber/LeCren removal/depletion method. After the initial assessment of stream parameters, two more phases are to be accomplished(Phase II, implementation and Phase III, monitoring).

The objective of this phase was to collect baseline data on selected streams tributary to Lake Roosevelt. The project field work was initiated in August, 1990 by personnel of the three co-operating agencies, the Confederated Tribes of the Colville Reservation (CCT), the Spokane Tribe of Indians (STI) and the Washington Department of Fish and Wildlife (WDFW).

Five streams were surveyed during 1990. Seventeen additional streams were surveyed during 1991. One stream (Blue Creek) is located on the Spokane Indian Reservation. Five streams are located on State and private lands in Stevens County WA. and the remainder on the Colville Indian Reservation. This report covers the results of data collection and analysis and final selection of streams for Phase II and III.

EXECUTIVE SUMMARY

The Lake Roosevelt Rainbow Trout Habitat/Passage Improvement Project is a mitigation project intended to partially mitigate for Fish and Wildlife losses suffered because of the construction of Grand Coulee Dam.

The purpose of the Phase I study was to provide baseline data that will allow the selection of streams to be set-aside for habitat/passage improvements. Upon completion of the data collection and analysis the second phase of the project (implementation) began by improving the habitat and/or removing passage barriers.

Beginning in August of 1990 stream inventory began with the hiring of two survey teams. One team worked primarily on the Colville Indian Reservation while the second team surveyed areas on State and private lands on the east side of Lake Roosevelt.

In 1990, a single stream (Hunters Creek) outside the reservation border was surveyed. Hunters Creek flows through the town of Hunters, WA. In addition, four streams on the Colville Indian Reservation were surveyed that included S. Nanamkin, Louie, Westfork, and Gold Creeks.

In 1991,seventeen streams were inventoried these include: on the Colville Indian Reservation, Nineteen Mile Creek (19 mi.), Twenty One Mile Creek (21 mi.) Twenty Three Mile Creek (23 mi.), Twenty Five Mile creek (25 mi.), Thirty Mile Creek (30 mi.), North Nanamkin Creek, Bridge Creek, Iron Creek, Hall Creek, Lynx Creek and Sitdown Creek. On the former North Half of the Colville Reservation, Big Sheep Creek was inventoried. Blue Creek was inventoried on the Spokane Indian Reservation. Four tributary streams located east of the reservoir were inventoried including Deep and Onion Creeks near the town of Northport and Alder and Ora-Pa-Ken Creeks near the town of Fruitland.

All data was collected, recorded on Scantron bubble sheets and sent to the Center for Streamside Studies at the University of Washington. Subsequent data analysis and the implementation of the following criteria drove the selection process for selection of improvable streams. The criteria used for the selection process included consideration of the following parameters:

- Perennial flowing streams.

- Existing natural population of adfluvial rainbow **trout.**

- **Streams having historic use by spawning rainbow trout.**
- **Existing potential** for **increased use by adfluvial rainbow trout.**
- **Streams with high potential for successful restoration.**
- **Habitat data analysis to determine cost effectiveness of proposed habitat improvements.**

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INTRODUCTION

HISTORICAL BACKGROUND

The construction of Chief Joseph and Grand Coulee Dams completely and irrevocably blocked anadromous fish migrations to the Upper Columbia River. Prior to hydropower development the blocked areas supported large diverse fish populations including eleven salmonid species (Scholz et. al., 1985). The complete extirpation of anadromous fish stocks from this area reduced the native salmonid assemblage by approximately 64 percent and limited fisheries enhancement opportunities exclusively to resident fish. The adfluvial rainbow trout population in the San Poil River has been identified as one of two potential native salmonid stocks remaining within the Colville Reservation (Jerry Marco, Fisheries Biologist, personal communication). Potentially this rainbow population is closely related to indigenous summer steelhead that historically utilized the San Poil River Basin prior to the construction of Grand Coulee Dam. Historical stocking of non-indigenous rainbow trout stocks may have influenced this population, however until the stock origin is determined this population will be managed as if it were a native stock.

Since the loss of anadromous fish above Grand Coulee Dam, fishery enhancement measures have been limited on Lake Roosevelt. Lake Roosevelt is the reservoir created by the Grand Coulee Dam. A few short term fisheries surveys have been conducted on the reservoir along with the introduction of fish species by the Washington Department of Wildlife (WDW), Washington Department of Fisheries (WDFW), the Spokane Tribe of Indians (STI), the Confederated Tribes of the Colville Reservation (CCT) and the United States Fish and Wildlife Service. Studies have shown that existing spawning habitat in Lake Roosevelt tributary streams may be inadequate to sustain a rainbow trout *(Oncorhynchus mykiss)* fishery in Lake Roosevelt (Scholz et. al., 1988). Upstream migration passage barriers limit the amount of spawning and rearing habitat that might otherwise be utilized by rainbow trout. Limited stream surveys and habitat inventories indicates that a potential for increased natural production exists. The lack of any comprehensive enhancement measures prompted the Upper Columbia United Tribes Fisheries Center (UCUT), Colville Confederated Tribes (CCT), Spokane Tribe of Indians (STI) and Washington Department of Fish and Wildlife (WDFW) to develop a comprehensive fishery management plan for Lake Roosevelt (Scholz et. al., 1988).

This project partially satisfies BPA's responsibility to mitigate for anadromous fish losses in the blocked area above Chief Joseph and Grand Coulee Dams. Additionally, the project is consistent with the State of Washington and Colville Tribal goals to enhance potential native salmonid populations where possible, while providing for the consumptive and non-consumptive utilization is consistent with the goals and objectives of the Tribe and with the State of Washington. It is also consistent with the Council's 1994 Fish and Wildlife System Goal and the Resident Fish Goal. Enhancing one of the few remaining potential native stocks within the reservation in locations that appears to have habitat enhancement possibilities has merit, particularly in the blocked area that has had extreme habitat degradation and native species extirpation. The project employs a logical path of preliminary investigation, strategic plan of action and monitoring and evaluation. The Lake Roosevelt Rainbow Trout Habitat/Passage Improvement Project was designed with amended into the Northwest Power Planning Council Fish and Wildlife Program in 1987(program measures 903 (g)(1)(c)(d)(e)).

GOAL

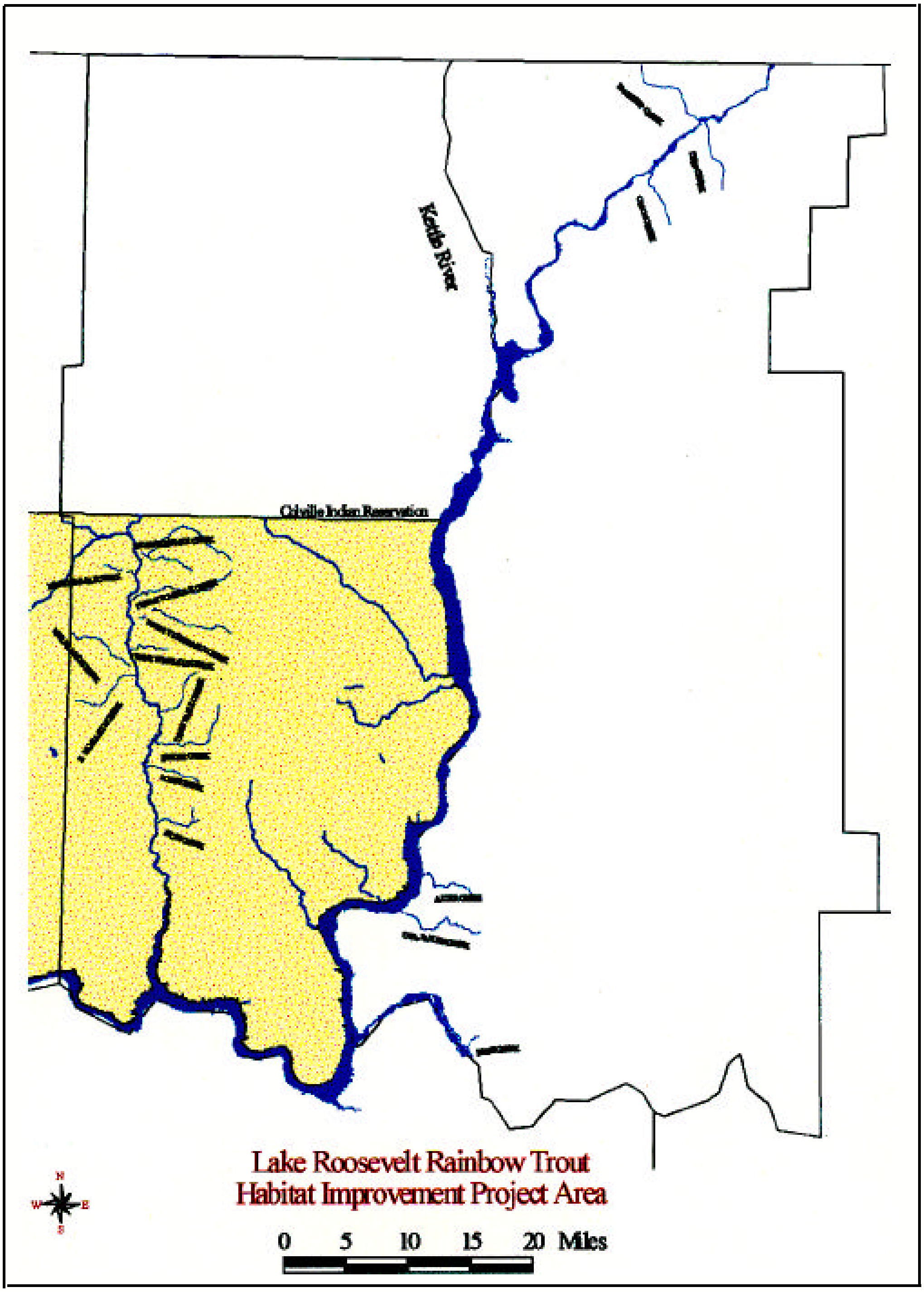
The goal of this project is to increase the quality and quantity of rainbow trout spawning and rearing habitat available with an emphasis on increasing the survival of wild and/or natural stocks. This goal will be achieved by protecting and improving the habitat of the stocks indigenous to Lake Roosevelt. Ultimately, this will increase the contribution of adfluvial rainbow trout to the fishery in the lake. A habitat passage improvement plan will be developed using the data collected by field teams from the three co-operating agencies, Colville Confederated Tribes (CCT), Spokane Tribe of Indians (STI), and Washington Department of Wildlife (WDW). Stream improvements will be accomplished using established methodologies developed by Dr. Jim Reichmuth and/or Dr. David Rosgen. Projects that will remove passage barriers, reduce sediment loading, improve or protect existing riparian vegetation, provide habitat diversity and protect the genetic integrity of rainbow trout within the system, will be prioritized for implementation. Improvements may include removal of passage barriers, realignment of stream channel, resetting culverts, re-establishment of stream meanders, and addition of log stump, rootwad and boulder structures in selected streams. Some streams only need to have a culvert re-installed on grade to eliminate a passage barrier. Others will require the use of several structures to create better habitat and diversity. Finally, the project will utilize TFW ambient monitoring methodologies to monitor and evaluate the effects of improvements on all physical and biological parameters enumerated during the course of the project. Collection of baseline data will include classification and enumeration of stream parameters including riparian vegetation, population estimates, biomass and densities.

DESCRIPTION OF STUDY AREA

Lake Franklin D. Roosevelt reaches upstream from the Grand Coulee Dam, 151 miles to the Canadian border. Approximately 494 miles of shoreline exist where sixty five (65) tributary streams contribute their flow and biomass to the fishery in the lake. The shoreline and study area are bordered by Ferry, Stevens, Spokane, Lincoln, Grant and Okanogan Counties.
The area lies within the Okanogan Highland geological district. The land habitat surrounding this lake is diverse; habitats range from coniferous forest, lush lowlands to semi-arid shrub steppe. Annual rainfall regimes (10-30 inches/year) greatly affect the climate of the area. Annual temperatures range from winter lows of -40 degrees F. to summer highs of lOO+ degrees. F.

This project is located in the Upper Columbia Sub-region above the blocked area created by the construction of Chief Joseph and Grand Coulee Dams. Specifically the project is located on the Colville Reservation and enhances resident fish populations as mitigation for anadromous fish losses (resident fish substitution) and is considered in-place and out-of-kind mitigation.

MAP 1. PROJECT AREA



SCOPE OF PROJECT
This project will be carried out in three phases.

PHASE I: Data Collection
Baseline data collection and analysis determined the quality and quantity of existing habitat, rainbow trout *(Oncorhynchus mykiss)* population estimates in unimproved streams and locate and record all passage barriers. [Note: cascade habitats were delineated by riffles >3.5%- this may bias some of the data1

The objectives for Phase I were to:
a) Conduct an extensive, comprehensive survey of selected streams to assess existing habitat/passage conditions.

b) Determine what type or types of habitat enhancement would be required in each of those streams to increase spawning or rearing habitat.

c) Prioritize those streams surveyed for enhancement work.

PHASE II: Implementation
Design improvement plans based on stream improvement methodologies of Rosgen and Reichmuth for selected streams and commence implementation.

PHASE III: Monitoring
Monitoring of habitat and improvements in streams to determine success/failure of improvements.

PHASE I: BASELINE DATA COLLECTION

This phase will be carried out by personnel from the three co-operating agencies, the Colville Confederated Tribes, Spokane Tribe of Indians and the Washington Department of Wildlife.

Baseline data will be collected on selected streams within the Colville Indian Reservation, Spokane Indian Reservation, State lands and privately owned lands where streams flow into Lake Roosevelt.
All pertinent parameters will be assessed that include:
1) Horizontal Controls
2) Stream Channel Substrate
3) Gravel Embeddedness

4) Habitat Data
5) Passage Barriers
6) Stream Flows
7) Rainbow Trout Population Estimates
8) Trout Biomass and Density Estimates
8) Stream Temperature and Areas of Sub-Surface flows

NETHODS
Data collection will involve the Timber, Fish, and Wildlife (TFW) ambient monitoring methodology handbook (Ralph, 1990), developed for the Northwest Indian Fisheries Commission (NWIFC) in cooperation with the Center for Stream Side Studies at the University of Washington. Methodologies for the assessment of individual habitat parameters are listed in the appendix.

PHASE II: INPLEWENTATION

Following the completion of baseline data collection all data will be evaluated including the historic use of streams by adfluvial rainbow trout *(Oncorhynchus mykiss).* Evaluation of analysis will determine streams that can be improved with the largest gain per dollar spent.

PHASE III: MONITORING

The first spring season following the completion of the implementation phase, the project will begin the monitoring phase. The monitoring phase will be conducted using the same methodologies as before (TFW ambient monitoring).

1990 BASELINE DATA COLLECTION

METHODS
The interagency team of the Colville Confederated Tribes (CCT), Spokane Tribe of Indians (STI), Washington Department of Wildlife (WDW), and the Upper Columbia United Tribes (UCUT) selected the streams for habitat evaluation. Streams were selected based upon knowledge and data recorded by the cooperating agencies. The following criteria were used to assist with the stream selection: Streams with perennial flows, streams with existing and historic use by spawning adfluvial rainbow trout, streams with existing potential for use by adfluvial rainbow trout and streams where the potential outcome was cost effective.

Initial stream surveys began in August of 1990 by an interagency team consisting of fisheries technicians from the Colville and Spokane Indian tribes, and the Washington Department of Wildlife.

Stream lengths were divided into valley segments using TFW methodologies based upon geomorphic characteristics of the local landforms. Four streams on the Colville Indian Reservation were surveyed along with a single stream in southern Stevens County. Stream habitat types were classified and measured. Other stream parameters were noted such as flow, gradient, seral stage, and stream canopy. Substrate size, quantity, and degree of embeddedness was determined and recorded. The degree of embeddedness has a direct bearing on trout reproduction success. Other criteria evaluated included presence or absence of woody material in the stream channel. The size, type, and location were recorded for future consideration. Data for streams surveyed appear in Table 1 and 2.

Population estimates were done on all study streams using the Seber-LeCren removal depletion method. These estimates were later used to calculate densities per/km and biomass per/m^2. Population estimates of rainbow trout *(Oncorhynchus mykiss)* by stream were calculated at 95% confidence intervals. Further calculations were conducted resulting in biomass figures and densities per kilometer.

TABLE 1. STREAMS SURVEYED and POPULATION CHARACTERISTICS- 1990.

Stream	**Length (km)**	**Population Est.***	**Number per KM.**
Louie Creek	4.5	1,510 +/ 120	360
S. Nanamkin Creek	4.6	1,610 +/ 260	610
Westfork Creek	8.6	1,360 +/ 300	158
Gold Creek	7.3	1,380 +/ 250	190
Hunters Creek	15.6	7,820 c/ 990	1,104
TOTAL SURVEYED	40.5		

*ONLY RAINBOW TROUT.

TABLE 2. FISH BIOMASS PER SQUARE METER- 1990.

Stream	Cascade	Riffle	Pool	Average for stream
Louie Creek	2.2	2.5	17.2	4.8 g/m^2
S. Nanamkin Creek	0.2	5.9	7.3	3.0 g/m^2
Westfork Creek	0.7	0.4	2.0	0.7 g/m^2
Gold Creek	0.2	0.4	3.9	0.6 g/m^2
Hunters creek	2.9	5.6	4.8	5.2 g/m^2

Trout populations in all project streams are maintained by natural production. Foot surveys conducted during spring of 1990 and earlier substantiate the use of project streams by adfluvial rainbow trout for spawning activities.

Pool-riffle-cascade ratios were calculated for each valley segment of all surveyed streams. Ideally a 1 to 1 ratio of pools to riffles is needed for good trout production (Hunter, 1990). Pool riffle ratios by valley segment are seen in various tables in this report. These figures are based on area in square meters.

Project Streams Narrative Discussion- 1990

TABLE 3. GENERAL STREAM DATA- 1990.

STREAM	SEGMENT	LENGTH	P/R/C RATIO	GRAD-IENT	AVERAGE CANOPY CLOSURE %	LWD >6 inches/ KM.
LOUIE CREEK	VS #1(F-4)	2,430m	1/6/1	3.6%	49	54
	VS #2(U-3)	2,108m	7/29/ 1	3.7%	66	9
SOUTH **NANAMKIN** CREEK	VS #1(F-4)	877m	1/6/1	1.1%	47	0
	VS #2(F-3)	761m	2/1/2	2.8%	48	34
	VS #3(V-1)	2922m	3/1/5 00	3.2%	41	38
WESTFORK CREEK	VS #1(F-4)	7,537m	1/9/. 5	1%	24	14
	VS #2(U-2)	1,070m	2/9/1	1.5%	NA	8
GOLD CREEK	VS #1(F-4)	5,158m	1/7/4	2%	35	20
	VS #2(V-1)	2,094m	2/9/1	2%	22	26
HUNTERS CREEK	VS #1(V-1)	240m	3/1/2	3%	46	33
	VS #2(U-1)	7,041m	6/7/1	2.7%	41	18
	VS #3(U-3)	8,280m	3/32/ 1	1.5%	45	43

TABLE 4. SUBSTRATE DATA (GENERALIZED CATEGORIES)- 1990.

STREAM	SEGMENT	SAND%	GRAVEL%	COBBLE%	EMBEDDEDNESS
,LOUIE CREEK	VS #l(F-4)	9	62	29	5-25
	VS #2(U-3)	5	75	20	> 75
SOUTH NANAMKIN CREEK	VS #1(F-4)	18	70	12	50-75
	VS #2(F-3)	4	64	30	5-25
	VS #3(V-1)	6	76	la	50-75
WESTFORK CREEK	VS #l(F-4)	0	32	68	5-25
	VS #2(U-2)	1	23	76	5-25
GOLD CREEK	VS #l(F-4)	1	91	8	50-75
	VS #2(V-1)	0	21	79	>75
HUNTERS CREEK	vs #l(V-1)	2	90	a	25-50
	vs #2(U-1)	0	84	15	so-75
	vs #3(U-3)	1	90	9	SO-75

TABLE 5. STREAM TEMPERATURE(c) DATA- 1990.

MONTH	LOUIE CREEK	SOUTH NANAMKIN CREEK	WESTFORK CREEK	GOLD CREEK	HUNTERS CREEK
APRIL	6.0	6.6	5.8	5.9	6.4
MAY	7.0	7.0	6.5	6.8	8.0
JUNE	7.7	8.0	7.0	7.5	9.0
JULY	9.5	10.0	16.0	9.0	11.0
AUGUST	15.0	13.0	16.0	11.0	16.0
SEPTEMBER	11.0	11.0	14.0	14.0	15.0
OCTOBER	8.0	5.0	9.0	7.0	9.0
NOVEMBER	3.0	3.0	4.0	2.0	4.0
DECEMBER	3.0	3.0	3.0	3.0	4.
AVERAGE	7.8	7.4	9.0	7.4	9.2

TABLE 6. STREAM FLOWS(CFS) DATA- 1990.

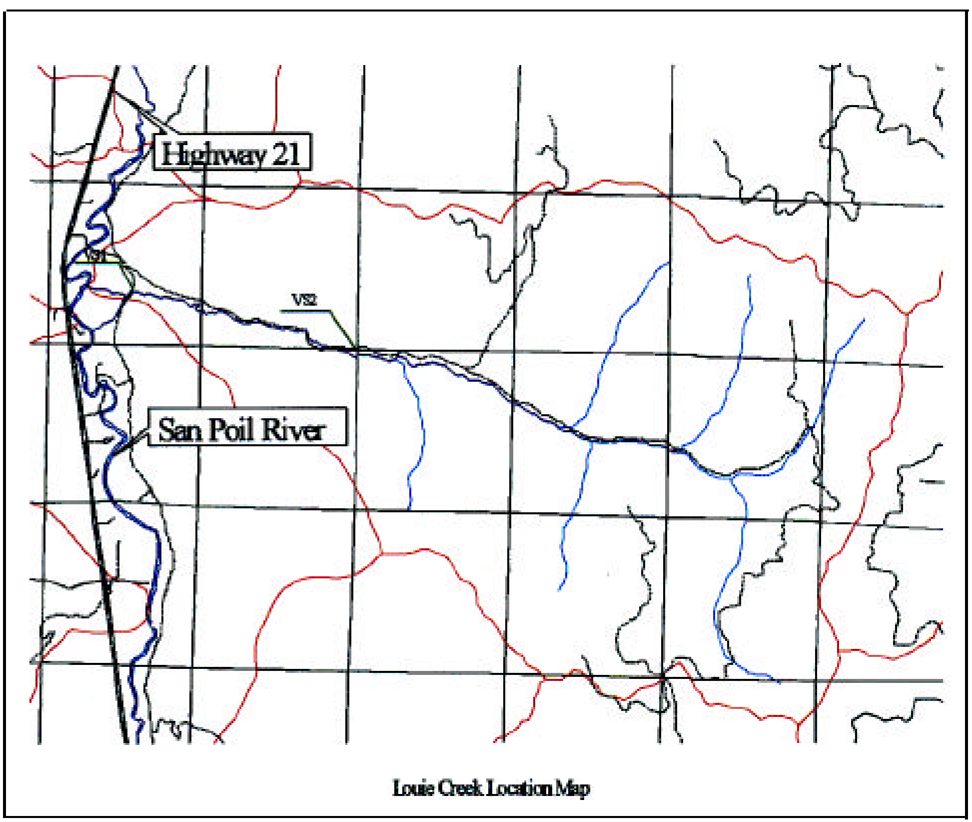
DATE	LOUIE CREEK	SOUTH NANAMKIN CREEK	WESTFORK CREEK	GOLD CREEK	HUNTERS CREEK
4/24/90	3.6				
7/11/90			24.5	10.8	
7/25/90		1.5			
8/14/90					4.5
LOW FLOW	3.1	3.1	VS1 19.4	8.0	4.5
			VS2 11.7		VS3 2.9

Louie Creek

PHYSICAL DESCRIPTION

Louie Creek is a major third order, rainbow trout producing tributary flowing from the east side of the San Poil River drainage. The drainage area for Louie Creek is 20.8 square kilometers and main stem length is 8.7 km (5.2 mi.). The upper reaches of Louie Creek are intermittent in extremely dry years, but the first segment goes dry on an annual basis due to the glacial outwash soils. The confluence with the San Poil River is at rkm 35.6 (21.3 mi). The upper reach (VS #2) of the stream flows through a broad U-shaped valley sparsely covered with ponderosa pine. The lower reach (VS #l) of the stream flows into a large valley floodplain where it joins the San Poil River. Both reaches of this stream exhibit impacts associated with the dirt road along the stream, past logging actively up stream, and livestock grazing. The road impacts include sediment loading and

MAP 2. LOUIE CREEK MAP



poorly installed (perched) and undersized culverts. The riparian area in both reaches consisted of the following species: cottonwood *(Populus trichocarpa),* ponderosa pine *(Pinus ponderosa),* alder *(Alms spp.),* Douglas fir *(Pseudotsuga menziesii)*, red *osier* dogwood *(Corms stolonifera),* black hawthorn *(Crataegus douglasii),* and various grass and forb species.

METHODS AND DISCUSSION

TFW ambient monitoring methodology divided Louie creek into two valley segments (VS) identified by gradient, valley bottom and side slope geomorphic characteristics. Valley segment #1 is the lower most reach of the stream, has a segment length of 2,430m, and an average gradient of 3.6% (Table 3). Valley segment #2 extends upstream 2,108 M. with a mean gradient of 3.7% (Table 3).

Data analysis (i.e., sediment transport and flow dynamics, stream bank process, plant establishment and plant community succession) indicate that Louie Creek has the potential to be a high producing fisheries tributary. Data analysis further reveals that unfavorable pool/riffle ratios prevent rearing potentials from being met (Table 3). Criteria used for substrate breakdown is presented in Appendix C.
Substrate sample analysis determined that embeddedness ranged from 5-25 percent in valley *segment* 1 and as high as > 75% in segment 2 (Table 3). Observations indicate high embeddedness levels in VS #2 are probably a result of spring runoff events. Substrate composition for gravel, sand and cobble make-up the entire substrate accounting for 86.0%, 9.1% and 4.9% (Figure 1) of the substrate, respectively, VS #2 substrate composition was 93.7% gravel, 4.7% sand followed by 1.6% cobble (Figure 1).

Flows in the lower reach of VS #2 are seasonally intermittent. Two stream sections 200 to 300 meters in length have late summer intermittent flows. The upper reach of VS #2 had a low flow discharge of 0.32 cubic feet per second (cfs) in August 1990 and a high of 6.7 cfs in April 1991, while the lower reach, VS #1 of Louie Creek had a low flow discharge of 3.1 cfs in August 1990 and high of 6.8 in April 1991.

Water temperatures ranged from a low of 3°C in November and December to a high of 15°C in August of 1990. Spring time temperatures of 6°C and 7°C for April and May 1991 respectively were recorded.

Instream cover observations were noted and analyzed. Analysis indicates that the preferred substrate size (10-30 cm.- see appendix) for rearing by young rainbow trout (10-15 cm in length) makes up 28% of the substrate in both valley segments (Figure 1).

Instream cover for rainbow trout consists of large woody debris (LWD) and averages 5 pieces of either woody debris (> 10 cm dia) or rootwads every 100 m. Cover provided by over hanging vegetation was dense in the upper reach of VS #2 and sparse in the remaining part of VS #2 and VS #1.

Species composition in Louie Creek is limited to a single specie, rainbow trout (Oncorhynchus *mykiss).* Population estimates calculated for VS #1 was 950 ± 160 RBT, while VS #2 estimate was lower at 660 ± 90. The entire stream population estimate was calculated to be 1610. Rainbow trout habitat utilization indicates that older rainbow trout (2+) utilized pools at a rate of 100% in VS #1 and 67% in VS #2 or 92% over all. The 1+ age class rainbow trout utilized pools to a lesser extent, 85% in VS #1 and 39% in VS #2. Riffles in both valley segments were utilized to a lesser degree by 0+ young of the year (YOY) rainbow trout. Twenty-one (21) percent YOY were sampled from riffles in VS #1 and 62% in VS #2. Overall fish from all age classes were found utilizing pools as opposed to riffles and cascades. Lower densities of older age classes (1+ and 2+) in VS#2 may be a function of the lack of woody debris or winter covers. As a result the 0+ mortality could be higher thereby reducing the year to year carry over.

Fish density and biomass estimates were calculated using Fish-Pro software to analyze data collected during 1990 and are summarized in Table 1 and 2. Louie Creek ranks third (360 fish/km) when compared to the other study streams of 1990 in density per kilometer. Rainbow trout biomass in Louie Creek was low at 4.8 g/m^2 and ranks fourth in biomass. Data analysis indicates that pools contained the largest rainbow trout biomass at 17.21 g/m^2. The biomass contained in riffles was calculated at 2.23 g/m^2 with values for cascades at 2.34 g/m^2. The mean biomass value for Louie Creek was 4.7 g/m^2.

Sixty-one percent of the total RET population is made up of young of the year population, while the 1+ and 2+ age classes comprised 29% and 10% of the total respectively. No fish older than the 2+ age class were sampled during the survey period.

Population density data showed that the highest population densities of rainbow trout occurred in the riffle habitat (46%) while pool and cascade habitat followed with population densities of 44 and 10 percent respectively.

The rearing capacity of Louie Creek varies from segment to segment. Sixty percent of segment #1, offers good to excellent spawning rearing areas. A total of 1,458 meters are available. In valley segment #2 840 meters or forty percent is available.

Management Recommendations

Upstream passage barriers, subsurface flows, high embeddedness and lack of large woody debris are the primary limiting factors to the fisheries in Louie Creek.

The principle limiting factor in Louie Creek is the lack of suitable habitat for all life stages of fish, especially the young of the year age class. Removal/re-installation of passage barriers (above grade culverts) would provide access to upper areas with ample habitat available.

Increasing the pool-riffle ratios closer to the optimum 1:1 would also increase available habitat. This could be accomplished by the installation of instream structures that would create pools and provide winter cover. Addition of woody material to the stream bed would also provide some needed cover.

Project personnel recorded ample evidence of stone fly (Order P1ecoptera) and caddisfly (Order *Trichoptera)* presence.

Subsurface flows limit cover availability as well as up stream migration. Habitat improvements such as vegetation planting would help prevent some areas of subsurface flow by shading the creek, cooling the water and providing organic debris to the channel. A permanent change in the flow regime to perennial flows would improve migration time and rearing habitat.

South Nanamkin Creek

PHYSICAL DESCRIPTION

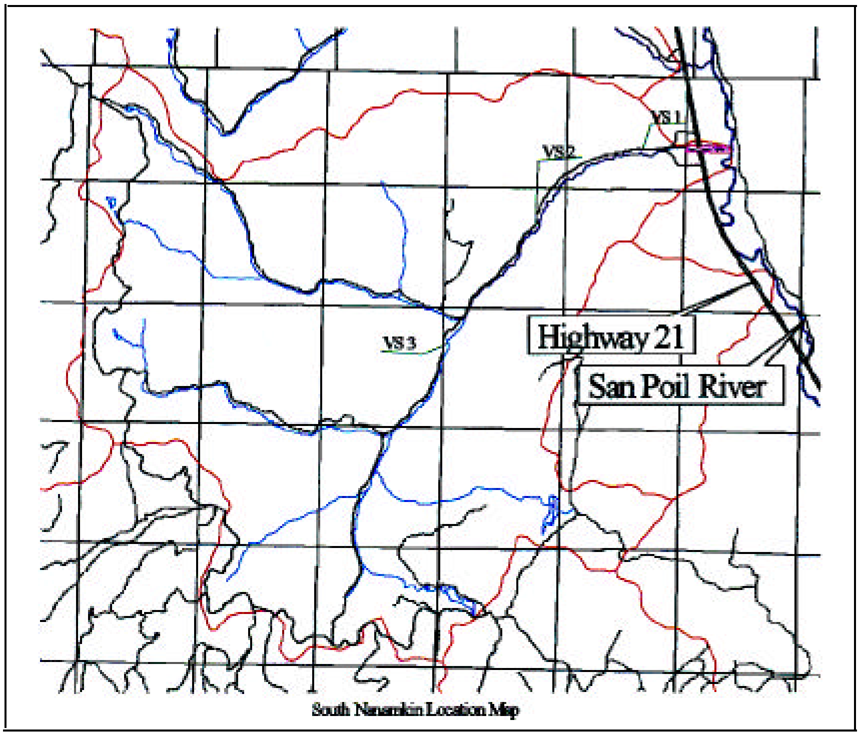
South Nanamkin is one of the largest rainbow trout producing streams tributary to the San Poil River (Table 1). It is a third order tributary of the San Poil River. The lower valley segment/stream flows over an alluvial fan (glacial outwash soils) in the San Poil Valley. This results in subsurface flows during the summer months causing an intermittent status. South Nanamkin creek drains sixteen (16) square miles and has a main stem length of 11.9 kilometers (7.1 miles) Subsurface flows were encountered during September 1990, consequently, monitoring efforts were restricted to 4.5 km (2.8 mi.).

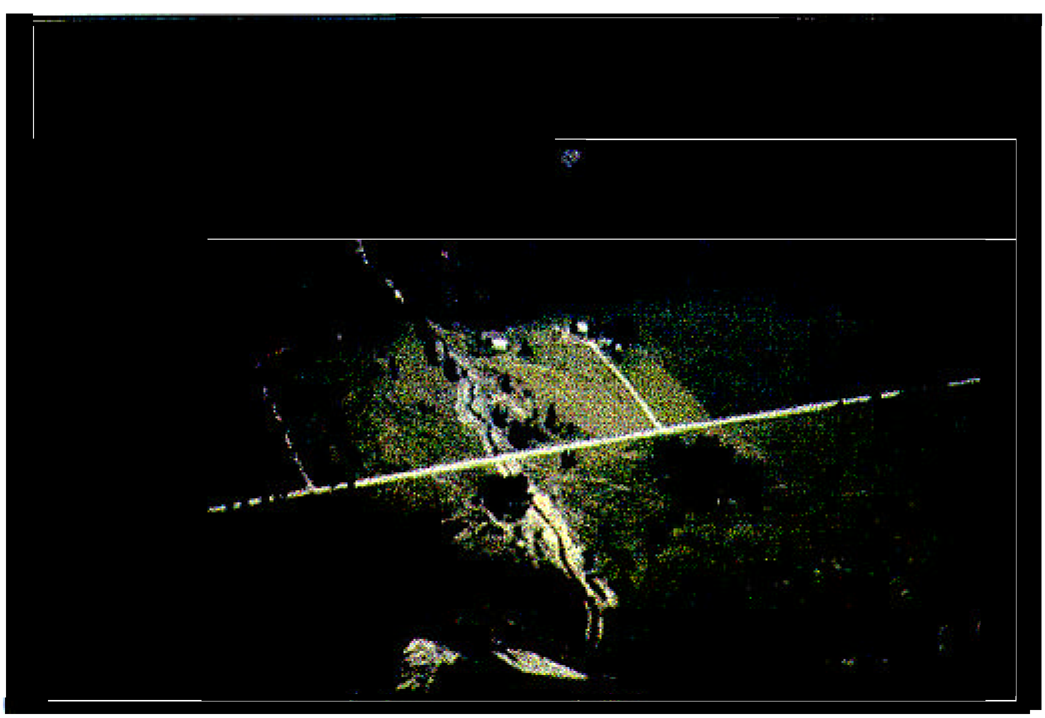
The middle segment flows through a broad U-shaped valley, while the upper segment flows out of a narrow V-shaped valley. The riparian area in the middle and upper valley segments are moderately dense consisting of ponderosa pine, Douglas fir, cottonwood, red osier dogwood, alder and various other brush, forb and grass species. The lower valley segment is devoid of riparian vegetation due to agricultural impacts, mostly livestock grazing. Upland areas are impacted by past timber harvest activities. A seasonally maintained dirt road parallels the stream and may contribute to sediment loading, but is not nearly as high an impact compared to other streams in the project.

METHODS AND DISCUSSION

Using T.F.W. ambient monitoring methodologies, the stream was divided into three geomorphic valley segments. Valley segment #1 begins at the confluence with the San Poil River, has a mean gradient of one percent and a valley segment length of 877m (Table 3). Valley segment #2 is the middle portion of the stream with a mean gradient of 2.8% and length of 761m. Valley segment #3 extends from VS #2 a total length of 2922m. with a mean gradient of 3.2%. The total survey length of South Nanamkin Creek is 4,560m (Table 3).

MAP 3. SOUTH NANAMKIN CREEK MAP AND AERIAL PHOTO





Substrate data analysis indicates that substrate embeddedness ranges from 50-75% in VS 1, 5-25% in VS 2 and 50-75% in VS 3 (Table 4). Substrate make-up (sand/gravel/cobble) found in VS #3 is ideal for rainbow trout production due to low levels of sediment deposition and large quantities of gravels (Table 4). Substrate sizes fall within the range preferred by rainbow trout (Hunter, 1990). Boulder and cobble make up the majority of fish cover in segment No 3.

In the lower reach, subsurface flows occur during late summer (August and September). No riparian vegetation exists in this area due to agricultural practices. Anecdotal information indicates that perennial flows once existed. The riparian zone vegetation is more than adequate in the upland areas. Vegetation present in the upper portion of VS #1 consists of large cottonwood, ponderosa pine, willow, various brush, forb, and grasses. In the lower segment, cover provided by over-hanging vegetation is very limited, as are undercut banks.

Average discharge data collection for all valley segments was 3.1 c.f.s. (Table 5). These values were calculated during summer low flow periods. Velocity was adequate for preferred spawning site selection (0.4 to 0.64m/s) (Burton, Harvey, and McHenry, 1989).

Canopy closure average densities for all valley segments combined is 45%.

Pool-riffle-cascade ratio found in VS 2 is 2/1/5 which is somewhat close to the ideal of l/l/l (Hunter, 1990). The ratio for VS #3 was 3.2/1./5.1. This offers excellent rearing habitat for all aye classes of fish.

Annual water temperature ranged from 3° C in November to a high of 13° C in August.

In valley segment 2 fish habitat is mainly undercut banks, over hanging vegetation, woody debris and boulders. Valley segment #3 provides adequate amounts of fish cover. Overall, the riparian zone on South Nanamkin is in fair condition. In the lower segment, a riparian restoration project and time would improve the impacted areas.

The species composition of South Nanamkin Creek is made up of rainbow trout (*Oncorhynchus mykiss*) exclusively. Total population estimates for all age classes was 1,660 ± 260 fish. Estimates were calculated for the 0+ aye class at 870 ± 160; for the 1+ age class 530 ± 40, for the 3+ aye class 210 ± 60, and less than fifty for other age classes.

Population densities (Table 1 and 2) are based on data collected from all three valley segments. Based on a sample size of 81 fish, 53% of the 0+ fish were found in pools and 43% were found in riffle habitat. The 1+ fish were also more abundant in pools at 54% v.s. 42%. The 2+ fish were more abundant in riffle habitats with 81% of the sample in riffle habitat while only 19% were found in pools. In V.S. 2 fifty-four percent were in pools, 42% in riffles and 4% in cascades. For age 2+ fish, with a sample size of 21, 81% were found in pools, 14% in riffles and 5% in cascades. The aye 3+ fish were only found in pool habitats. Pool rearing habitat was abundant for all age groups.

Age class relative abundance by valley segment reveals that 0+ age class fish made up the highest percentage in all three valley segments.

Biomass calculations in grams/m^2 were done for each habitat type. Pools habitat supports the largest biomass figure at 7.26 g/m^2. Riffles were second at 5.85 g/m^2 and cascade types at 0.22 g/m^2. Biomass based on valley segment are lower. Valley segment #1 has the lowest figure of .07 g/m^2. Valley segment #2 has the highest at 3.08 g/m^2. Valley segment #3 has a biomass of 1.09 g/m^2. The higher biomass figures found in V.S. #2 and V.S. #3 reflect the perennial flows and optimum rearing condition. Condition factors for all fish aye classes were good. Overall in South Nanamkin Creek, rainbow trout biomass figures were very low (0.29 g/m^2). The density of 720 fish/km, in segment 3 is higher than the other 2 segments.

Habitat utilization data reveals that pools are utilized 59% compared to 33.4% and 7.4% for riffles and cascades. In South Nanamkin riffles contain 73 fish/m or 730 fish/km. These may be a reflection of pool crowding or lack of pool types.

Primary limiting factors in South Nanamkin are passage barriers and lack of adequate rearing/wintering cover. In order of upstream encounter, passage barriers are; summer sub-surface flow, above grade culvert, improperly designed irrigation diversion and inadequate culvert size under two concrete fords. Passage barriers reflect directly on biomass totals, fish per meter and per kilometer found in upstream areas.

Stream rearing capacity in this stream is low in both lower segments. In segment one subsurface flows are the cause of the lack of rearing capacity. In valley segment #2 431 meters are located immediately below the second culvert. The culvert and irrigation diversion upstream restrict entry into the upper area of V.S. #2. A total of 2,464 square meters of spawning/rearing habitat are present above the barrier(s). In valley segment #3 approximately 50%, or 4800 square meters, are present.

Management Recommendations

The primary limiting factor for rainbow trout production in San Poil River tributaries is the lack of suitable habitat brought about in part by annual subsurface flow events. Areas of subsurface flow may prevent upstream migration and limit spawning and rearing habitat.

In the upland area, two concrete fords exist that are no longer used. They should be removed or replaced with larger, adequate sized structures. The lower culvert (at Highway 21) requires work to stabilize the bank on both upstream and downstream ends. The plunge pool downstream needs to be reconstructed to provide a rest area for migrating fish. The existing irrigation diversion needs reconstruction to provide an operating gate to control flow and rechannelization of the bypass area to limit water usage. This effort will help prevent dewatering episodes from occurring. The existing pool-riffle ratio should be altered closer to the desired 1:1 ratio (Hunter, 1990). Installation of stream structures would help briny this unfavorable ratio closer to the desired ratio. Critical winter cover could be provided by the addition of large boulders and woody debris. Based on Colville Tribal Fish and Wildlife Department data, substantial spawning and rearing habitat are available above the blocked area. South Nanamkin Creek will be selected for future enhancement efforts.

Data analysis reveals that subsurface flows are a problem in South Nanamkin Creek. Additionally, perched culverts in the uplands and an undefined channel at the mouth make up the majority of the problems in South Nanamkin Creek. Future enhancement efforts will entail stream channel modifications that will include channel reconstruction, alignment, and re-enforcement combined with riparian vegetation planting, and riparian corridor fencing along areas of subsurface flow. In addition to the channelization of the lower portion efforts will focus on the re-installation on grade of the perched culvert at the canyon mouth. The use of a bottomless arch culvert is recommended.

Westfork Creek

PHYSICAL DESCRIPTION

Westfork Creek, also known as the West Fork of the San Poil River is a third order tributary to the San Poil River draining 11.5 square miles with a mainstem length of 8.9 kilometers (5.4 mi). It is a perennial stream that flows in a easterly direction to its confluence with the San Poil River at rkm 70. The confluence is located approximately 8.9 k (5.38 mi.) down stream of the boundary between the Colville National Forest and the Colville Indian Reservation.

The upper valley segment flows through a low gradient U-shaped valley while the lower valley segment flows into a larger mainstem valley. The riparian vegetation in the upper valley segment is moderately dense with ponderosa pine, Douglas fir, cottonwood, alder, red osier dogwood, and western larch (Larix *occidentalis).* The lower valley segment riparian vegetation is sparse with the same species seen in the upper areas.

DISCUSSION

Westfork Creek, a perennial flowing stream, was divided into two valley segments. Valley segment #1 extends from the confluence with the San Poil River 1070m. upstream and has a mean gradient of 1.0% (Table 3). Valley segment #2 extends from V.S. #1 upstream 7,537m. with a mean gradient of 1.5%.

The substrate composition of V.S.#1 is made up of 80% assorted gravels, the remainder is small cobble. Valley segment #2 analysis places gravels at 60% and cobble at 40%. An embeddedness range of 5-25% was found in both valley segments.

Flow discharge ranges from 11.6 c.f.s.(segment #l) 6.1 cfs. In the upper segment. Flow measurements were taken at the summer low flow period during September 1990.

Riparian vegetation in both valley segments is moderate to sparse, with a mean canopy closure of 24%. The riparian zone in V.S. #2 was in fair condition. Available fish cover is limited with cover provided by low over hanging vegetation, small diameter woody debris, undercut banks, and boulders.

Fish habitat utilization in Westfork ranges indicates a preference for pool habitat over other types. Preferred substrate size for spawning, embeddedness, large woody debris, low over hanging vegetation, and undercut banks are all adequate or present for modest fish spawning and rearing. Stream temperatures ranged from a low of 4°C in November to a high of 16°C in July and August.

Biological characteristics of Westfork Creek include a species composition of rainbow trout *(Oncorhpchus mykiss),* eastern brook trout *(Salvelinus fontinalis)* and torrent sculpin (Cottus *rhotheus).* Only values pertaining to rainbow trout (RBT) were considered in this study.

Population estimates calculated for RBT in V.S. #1 (F-4) were 380 ± 150. The estimate for valley segment #2 is 1030 ± 160. Overall, the expanded population for Westfork is 1410 ± 310. Pool habitat contains 26 fish/100m, this figure is double that of riffles, and nearly double again that of cascades. In a sample size of 63, of all age classes of fish, 59% were rearing in pool habitats in V.S. #1. The 0+ age class make up the highest density at (54%) in pools in both valley segments. Riffle habitat is second in preference by all age classes in both valley segments.
Relative abundance by age class shows that age 0+ fish make up 63% of the total population overall. Population densities for Westfork Creek are low compared to other project streams.

Rainbow trout biomass (0.75 g/m^2) is low when compared to Hunters and Louie Creeks. Westfork Creek has ample stream rearing capacity in the lower valley segment. Ninety percent of the lower segment contains areas of excellent spawning and rearing habit. In the upper area thirty percent is available for spawning and rearing.

The primary production limiting factor identified is the lack of woody debris that provides cover combined the low pool/riffle ratio. The lack of woody debris in all streams may be the major contributor to the long term instability of the population. Undercut banks provide the majority of cover for all age classes in both segments.

Management Recommendations
Alteration of the pool/riffle ratio to a more desirable ratio would enhance the existing habitat and create more available habitat. This could be accomplished by installation of instream structures to provide cover for different age classes. Additional placement of rootwads, large woody material and boulders would greatly enhance the present habitat while creating the needed critical winter cover.

Stream bank plantings along selected portions of the lower valley segment would also shade the stream and provide thermal protection for the biota in the water. Habitat enhancement/improvement opportunities are somewhat limited in Westfork Creek. Improvements to other streams would undoubtedly provide greater benefits to the fishery.

Gold Creek

PHYSICAL DESCRIPTION

Gold Creek is a perennial, fourth order tributary of Westfork Creek, it **drains a** 43 square mile area with a mainstem length of 14.4 km (8.6 mi). It flows in a eastward direction out of Gold Lake (30 acres in size). Gold Creek is a perennial stream that flows through a narrow, low gradient U-shaped valley to its confluence with Westfork of the San Poil at rkm 4.3 (2.6 mi). The riparian zone is moderately developed with primarily large diameter cottonwood as the overhead canopy with red osier dogwood, hawthorn, and alder providing lower canopy cover. Sparse stands of Douglas fir and western larch are also present. Livestock grazing and logging activity are the primary land uses in the watershed. A dirt road runs parallel to the stream and contributes sediment to the channel. Gold Creek has ten intermittent fifth and sixth order tributaries that flow into it.

DISCUSSION

During the study Gold Creek was divided into two valley segments. Valley segment #1 has a gradient of 2.0% and a length of 6228m (Table 3). The gradient and length of V.S. #2 is 2.0% and 2093m respectively.

Substrate embeddedness in V.S. #1 ranged from 50-75% and >75% in segment 2. Substrate size was in the preferred range for rainbow trout spawning. Poor gravel conditions, (siltation and embeddedness) have undoubtedly reduced spawning success and macro-invertebrate diversity. In Gold Creek only 20% of the habitat is currently suitable for rainbow trout spawning.

The quantity of good fish habitat in Gold Creek is very limited. Very few areas of rearing habitat are available. Mean summer temperatures ranged from 2°C in November to a high of 14°C in September.

The species composition of Gold Creek is dominantly rainbow trout followed by eastern brook trout along with a few sculpins.

The lower valley segment (F-4) contains the largest population estimate of RBT at 780 $\pm$ 180 fish. The rainbow trout density per kilometer found in Gold Creek was. Population densities for this stream are low with 18 fish average per 100/m. Densities by habitat type are not characteristic of other project streams. Riffle habitats contained the most fish shocked with 47%; pools and cascade habitat types were 35% and 18% of the respectively. The biomass was considerably higher in pools versus the other habitat types(0.2g/m^2 in cascades, 0.47g/m^2 in riffles, 3.9g/m^2 in pools). The size of fish may indicate exclusion of small fish by larger ones in pool type habitat. Fish per 100 meters of pool, riffle and cascade habitat types was 49, 15, and 10 respectively.

Relative abundance by age class in Gold Creek reveals that the age 0+ fish make up the majority in both valley segments. The age 1+ class follows in relative abundance at a 20% average. Utilization of riffle habitats by 0+ YOY rainbow trout was common throughout Gold Creek, 85% of the 0+ rainbow trout sampled were found in riffle habitats. Fish occupying the cascade habitat were made up primarily by 1+ age rainbow trout. Overall, riffle habitat was used as the primary rearing area, during the time of electro-shocking, by all age classes with the exception of 3+ year class that used pool habitat. As in other project streams, the 0+ age class (970 $\pm$ 60) out number other age classes 3 to 1.

Biomass calculations in both valley segments in Gold Creek indicate identical figures of 0.61 g/m^2.

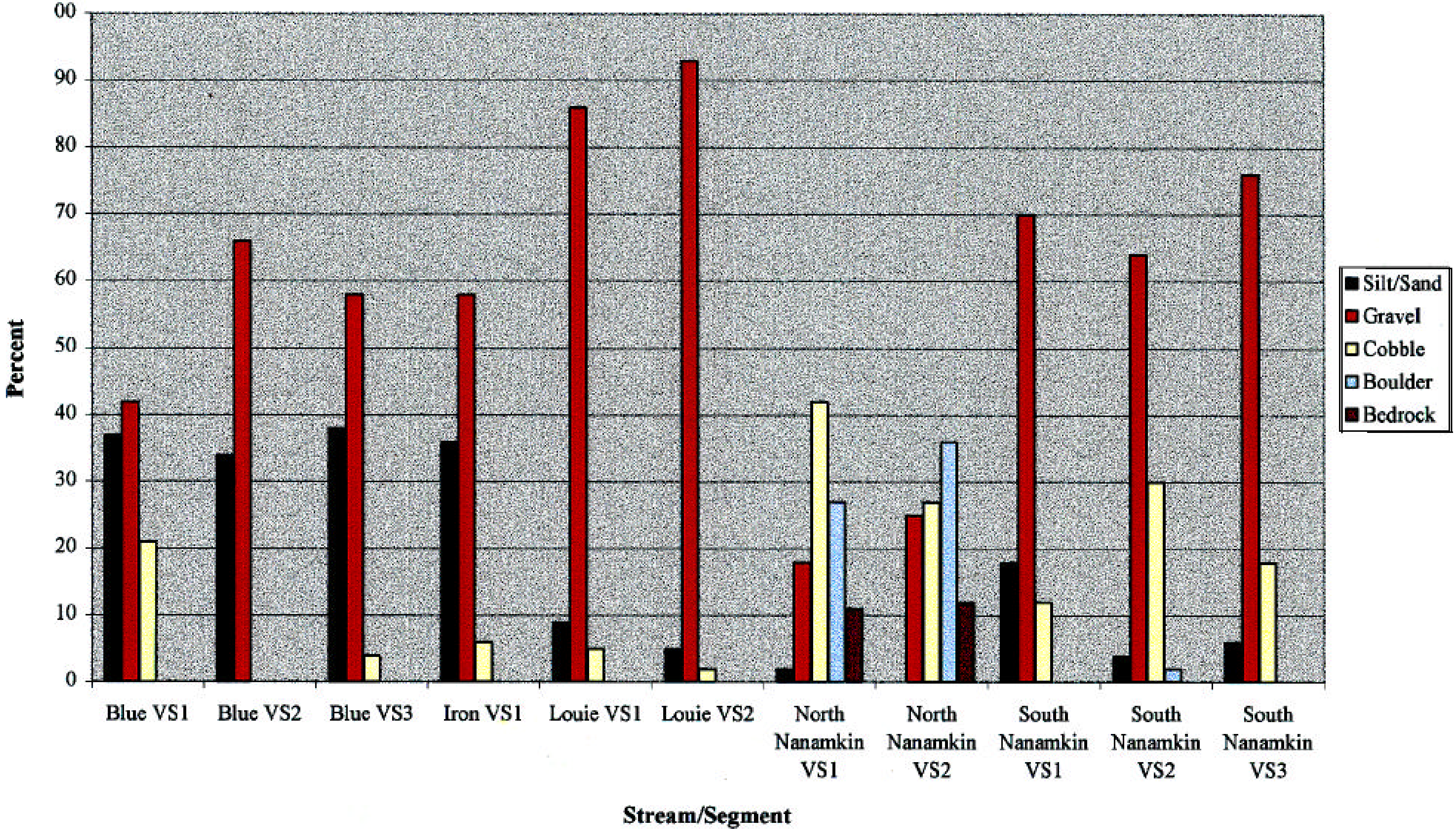
Riparian vegetation removal by livestock grazing, logging and high flow episodes has severely damaged the riparian area. Canopy closures in both segments averaged 28%. Fish cover within the stream is in fair condition, primarily made up of large woody debris and large boulders.

Rainbow trout production in Gold Creek is limited by lack of cover, high substrate embeddedness, and undesirable pool riffle ratios. Past logging activities, and the close proximity of the creek to a maintained dirt road are the probable cause of the embeddedness and to a certain extent the lack of rearing cover. The major factor regarding the lack of cover is related to the limited numbers of woody debris pieces.

In valley segment #2, many large beds of spawning gravel exist. Rearing habitat is limited to 209 square meters or 10% of the segment. The aforementioned lack of large woody debris and poor pool/riffle ratios are probably factors that contribute to the low rearing habitat availability.

Management Recommendations
Recommendations regarding this stream include the installation of instream structures that would provide winter cover, structure and aid in silt storage. Further recommendations would be to install rootwads and provide other organic debris for cover. As in Westfork Creek, the opportunities for enhancement/ improvement are limited and presently better opportunities exist in other streams.

Figure 1. Substrate Composition of Selected Streams.



Hunters Creek

PHYSICAL DESCRIPTION

Hunters Creek is located in southern Stevens County, east of Lake F. D. Roosevelt and north of the Spokane Indian Reservation. Hunters Creek is a perennial second order stream that flows out of the east slope of the Columbia River drainage into Lake Roosevelt. Hunters Creek is 24km (15 miles) long that has a drainage area of forty-one square miles.

The lower reach is bounded by a 70 foot waterfall. The falls permanently block upstream migration. Prior to the construction of Grand Coulee Dam, a small private hydropower operation supplied power to the Hunters community. The generation facility was located on the upper side of the falls and impounded a 15 acre lake. In 1938 the generating equipment was removed and the dam was intentionally breached. The mid-reach the stream flows through the town of Hunters and exhibits impacts associated with residential/business development (channel degradation, human wastes, residential runoff etc.). Riparian vegetation in this section includes cottonwood, ponderosa pine, alder and various ornamental shrub/tree species. The upper reach of the stream flows through a broad valley. Primary land use here is irrigated alfalfa hay production and other agricultural practices. The riparian area is nearly non-existent in many areas of this stream reach, although patches of alder, hawthorn, willow *(Salix spp.)* and various forbs and grasses are present. Several irrigation diversion structures impact stream flow during the summer irrigation season.

DISCUSSION

Washington Department of Fish and Wildlife historical data indicates the existence of a substantial resident fishery made up of eastern brook and rainbow trout. Rainbow trout densities found in Hunters Creek (500/km) place it second compared to other project streams. Biomass figures of Hunters Creek (5.2g/m^2) were the highest of the streams studied in 1990.

The gradients for valley segments #1, #2, and #3 are 3.0, 2.7, and 1.7 respectively (Table 3).

Biological factors indicate that Hunters Creek has the potential of being a high production trout stream. The data obtained during our study indicate that unfavorable pool/riffle/cascade ratios exist (Table 3) that limit potential production.. Pool/riffle/cascade ratio's by valley segment are V.S. #1 (1.8/1/1.8), V.S. #2 (1.9/7/1) and V.S. #3 (9.2/31/4/1) (Table 5).

Sediment deposition or embeddedness is high in all three valley segments. Valley segment #1 is lowest at 25-50% embeddedness. A large part of V.S. #1 is step pool cascade with the pools acting as sediment traps. Embeddedness is higher in V.S. #2 and V.S. #3 at 50-75% embeddedness (Table 4).

Substrate in V.S. #1 the is primarily medium gravel at 50% (Table 4, Figure 1) followed by 32% coarse gravel, 11% small gravel with sand and large cobble at 3.5% each. Areas of bedrock in the streambed were found in several places, but the percentage is small enough that it does not show up in averaged data.

Substrate in V.S. #2 was made up of solely of gravels, 35% pea gravel, 53% small gravel, 31% medium gravel, and 15% coarse gravel (Figure 1).

Fish habitat condition in Hunters Creek ranges from fair to excellent. The habitat in V.S. #1 is fair, mostly consisting of step pool cascades. In V.S. #2 the habitat is of low quality in the lower portion due to the heavy sediment depositions. Riffle habitat is dominant in V.S. #2 with a pool/riffle/cascade ratio of 1.9/7/1 (Table 3). Fish cover is provided by limited undercut banks or boulders. Areas of undercut banks were limited, but did provide the majority of the cover. Large areas of low gradient riffle exist in V.S. #3 (Table 3). The pool/riffle ratio here is 9.2/31.4/1.

Riparian vegetation in valley segment #1 is sparse to nonexistent. The riparian cover in V.S. #2 and #3 is sparse to moderate with some small areas of good cover. In V.S. #2 the lower half has sparse to no vegetation in the riparian area. Some areas of the upper part are excellent. This is true for V.S. #3 as well. Average canopy closure percent is presented in Table 3. Canopy closure readings for the stream average 43% with a range of 8% minimum to 84% maximum.

Mean temperatures ranges from a low of 4°C in November to a high of 16°C in August (Table 5).

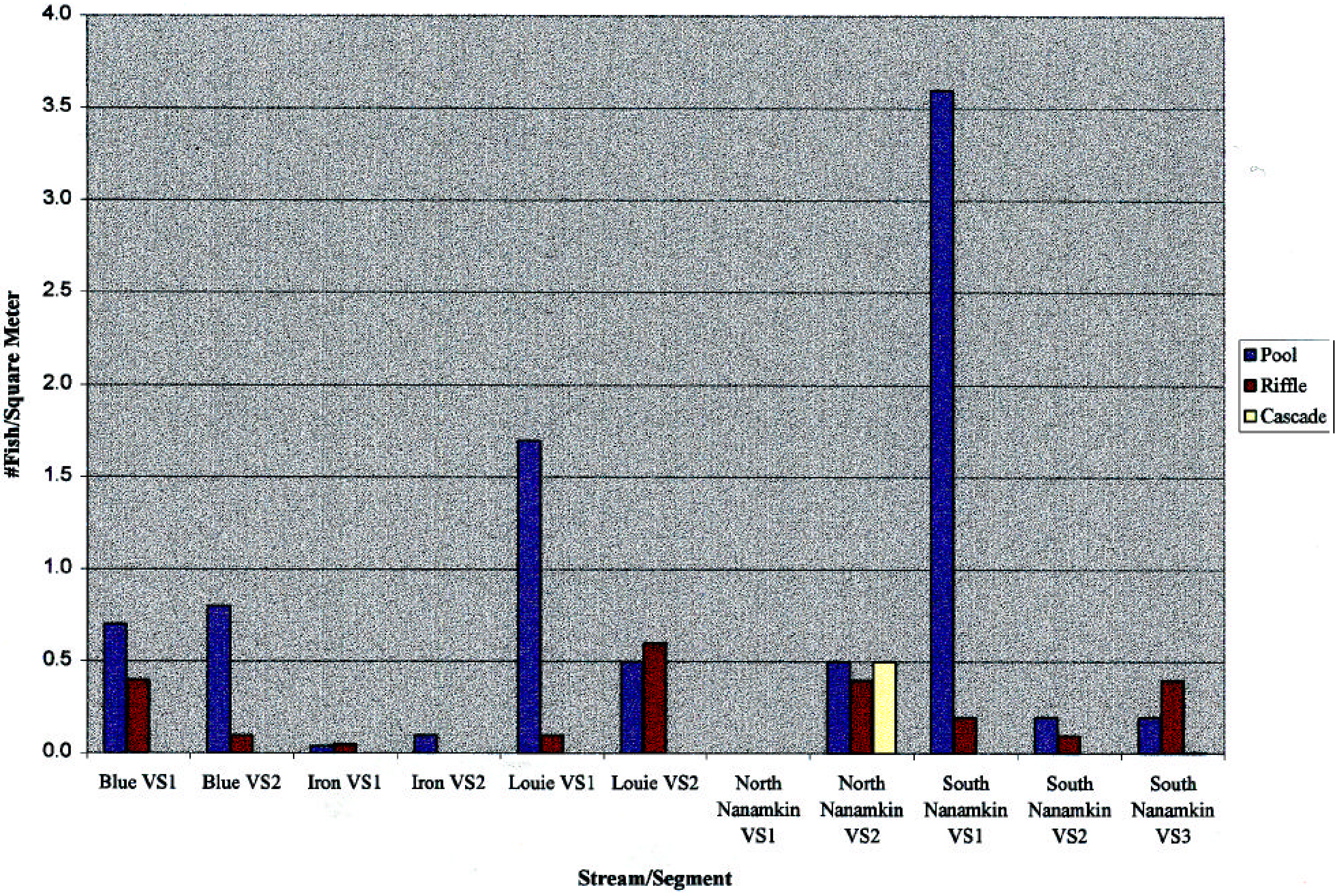
Habitat utilization data indicates that the age 0+ fish utilize riffle habitat at a 96% rate, pools and cascades are utilized as a 3% and 2% rate respectively. The age 1+ fish, for all segments, utilize riffles 85% of the time. The age 2+ and 3+ fish use riffles at 86% and 87% respectively. Ninety-five percent of the age 4+ fish use prefer riffle habitat. In valley segment #3 approximately 70% of the 8,280 square meters analyzed (5,796 square meters) is available or usable as rearing habitat. The primary land use of the upper half of valley segment #3 is timber production. In general, better habitat was found in the forested areas.

The species composition of Hunters Creek is more complex than other study streams. Rainbow trout dominate in all three of the valley segments, at an 86% average. Eastern brook trout- EBT *(Salvelinus fontinalis)* makes up a smaller portion of the total population, approximately 14% average, over the entire stream. In the lower valley segment RBT make up approximately 75% of the total and EBT 23%. Torrent sculpin (Cottus *rhotheus)* and bridge-lip sucker *(Catostomus columbianus)* make up 2% or less. No species other than rainbow and eastern brook trout were found above the falls.

Rainbow trout population estimates in Hunters Creek indicate a total population of 8260 ± 550. Valley segment #1 data has a population estimate of 630 ± 70 while V.S. #2 numbers equal 4660 ± 290 and V.S. #3 at 2970 ± 210. Age class analysis indicate that age 0+ fish numbers are 320 ± 30 fish in segment 1, while segment #2 has the largest population estimate for age 0+ fish of 1180 ± 90. The age 1+ fish dominate the population in V.S. #2 and 3 at 1540 and 960 ± 70 fish respectfully. Population numbers of age 3+ and 4+ fish are much lower in all three segments.

Relative abundance by the 0+ age class comprise 30% of the total population. The 1+ and the 2+ age classes of fish have a relative abundance of 30% and 25% respectively. The 3+ fish have a relative abundance of 13% with the 4+ being less abundant at 2% of the total population.

Figure 2. Fish Relative Abundance of Selected Streams.



Population densities rated by habitat types/segment are higher than any stream studied in 1990. Overall, riffle habitat yielded the highest number of fish electro-shocked- 72% of the total. Pools had 22% and cascade habitat was lower at 6%. Population estimates by habitat type shows that pools are highest with population estimates of 5430 $\pm$ 430. Population densities by age class indicates that the age 0+ fish comprise 30% of the population. The 1+ fish were 30%, age 2+ class is next in at 28% of the total, 3+ age class with 17% and the least found in the 4+ age class at 2%.

Biomass figures per habitat type in Hunters Creek were highest in riffles at 5.6g/m². Pools were next at 4.8g/m² with cascades following at 2.9g/m². The average biomass per square meter was calculated at 5.2g/m². Biomass figures per valley segment were 26.3g/m² in V.S. #1, 4.97g/m² in V.S. #2, and 0.74g/m² in V.S. #3.

The substrate found in V.S. #3 is made up of 61% medium gravel and 10% small gravel. Coarse sand and small cobble are also seen in this segment. High levels of embeddedness and silt deposition are present in V.S.#2 and V.S. #3 (Table 4).

Stream flows were taken at various times during the summer low flow period. The flows in the three valley segments #1, #2 and #3 were 4.59 cfs, 4.59 cfs, and 2.88 cfs respectively (Table 6).

Primary limiting factor, for adfluvial rainbow trout, found on Hunters Creek was passage barriers. The first barrier encountered is the 60 to 70 foot high Hunters Creek falls. Hunters Creek falls prevents upstream migration of all fish species. Further upstream, numerous small irrigation dams were encountered, including a 10 foot concrete dam that forms Caseys' Pond. Other man made dams and irrigation diversions exist along the stream within and near the town of Hunters. A second limiting factor is the lack of suitable rearing cover. Little cover is present in the first or second valley segments. The lack of cover in the second valley segment is due primarily to livestock grazing and agriculture. The low pool/riffle ratio also reduces the available rearing and over wintering cover.

Many small (un-permitted?) pumps exist within the town of Hunters that are used for lawn and garden water. Several sites exist within the Town of Hunters and outside that expel untreated sewage effluent into the creek which may affect pH, dissolved oxygen, turbidity, and macro-invertebrate populations. Previous work done by other agencies and interest groups indicate that macro-invertebrate populations (food source) are not a limiting factor for fish. Observation by technical personnel corroborate the existence of adequate numbers of macro-invertebrates including larva of mayfly (Order Ephemeroptera), stonefly (Order *Plecoptera),* caddisfly (Order *Trichoptera)* and dragonfly (Sub Order *Anisoptera).*

Management Recommendations

The fisheries above the Hunters Creek Falls warrants further study. A site evaluation and project feasibility study are recommended to determine if laddering or circumvention of the falls is feasible. A study of this type should include a joint community/tribe/agency effort. Land owners at the mouth expressed interest in helping defray costs associated with the circumvention of the falls or the re-establishment of the dam and lake above the falls.

Small volunteer projects could be accomplished that include the removal of small dams, beaver and debris jams, and un-permitted irrigation pumps. This would allow increased upstream or downstream migration to existing spawning areas. Community involvement in clean-up efforts by various groups such as FHA, 4-H, fishing clubs and agencies would help establish good rapport between land owners, Indian tribes and state agencies. Public education regarding water quality issues would also help further the water quality of the stream.

1991 BASELINE DATA COLLECTION

DISCUSSION

In 1991, following the cessation of spring high flows, ambient monitoring methodologies were applied to streams selected for baseline data collection. During the 1991 field season, a total of seventeen streams were surveyed (Table 7) and data analyzed. Stream survey lengths were dependant upon location of natural impassable barriers, such as waterfalls. Some streams were surveyed until they became very small and their potential contribution to the fishery was slight. Due to the length of time involved between actual data collection, analysis, and the writing of this report, some data has been lost (for both years, 1990 and 1991). This author will endeavor, to the best of his ability to write a complete and accurate report. This present author will draw on his personnel experience gained from data collection efforts while employed by the Washington Department of Wildlife as a fisheries technician on this project.

TABLE 7. STREAMS SURVEYED- 1991.

Stream	Length (km)	Land Owner
19 Mile Creek*		CIR
Big Sheep Creek	3.0	Private
Deep Creek	1.4	Private
Onion Creek	6.7	Private/NPS
Alder Creek	6.4*	Private/State
Ora-pa-ken Creek	3.8	Private/NPS
Blue Creek (SIR)	9.7	SIR
21 Mile Creek	1.4	CIR
23 Mile Creek	4.0	CIR
25 Mile Creek	1.0*	CIR
30 Mile Creek	27.5	CIR
North Nanamkin Creek	17.9	CIR
Bridge Creek	10.0	CIR
Iron Creek	5.0	CIR
Ball Creek	28.3	CIR
Lynx Creek	2.2*	CIR
Sitdown Creek	2.0	CIR
TOTAL	130.3	

The surveyed length for these streams are less than actual surveys; some of the data for these streams has been lost.

TABLE 8. GENERAL STREAM DATA- *1991.*

STREAM	SEG-MENT	LENGTH (m)	P/R/C RATIO	CC* %	LWD >6 INCHES /km.	WIDTH/ DEPTH RATIO	FLOW CFS (low)
BIG SHEEP	1	1103	0/.8/1	0	0	22.0	14
	2	1856	0/.5/1	34	0	9.2	11
DEEP	1	884	0/.3/1		0	32.9	4
	2	583	0/0/1		22		4
ONION	1	5675	.04/1/.2		1.4	3.8	6
	2	1050	0/0/1		0	7.0	6
ALDER	1	2906	.3/1/0	67	45	6.9	0.5
	2					2.3	
ORA-PA-KEN	1	1857	0/1/2		19	11.0	
	2	580	0.1/1/0			15.0	
BLUE	1	3128	3/36/1		3	9.4	0.7
	2	3355	5/1/0		9	5.2	
	3	3184	2/15/1		39	9.3	
21 MILE	1	1492	0/2/1		0	1.0	
	2	455					
23 MILE	1	1003	0/0.1/1		42	9.4	
	2	1886	0/0.5/1				
25 MILE	1						
	2	146	0.4/1/0		66	6.0	
30 MILE	1	7065	1.9/1/1		19	8.0	
	2	2405	2/46/1		21	3.7	
	3	5219				10.7	

	4	18038	4/4/1			7.3		
NORTH NANAMKIN	1	2978	0/0/1		0	6.0		
	2	12477	.1/5/1		20	8.4		
BRIDGE	1	1226	94/22/1		3	5.5		
	2	3161	.2/1/0		55	11.7		
	3	1762	.1/.1/1		92	9.1		
	4	3817	4/32/1		37	10.0		
	5	2928	1/1.1/0		264	8.9		
IRON	1	1189	.1/1/0		1	5.8		
	2	3865	80/0/1		17	9.0		
HALL	1	1429	0/0.2/1		8	8.6	15hi	
	2	7117	0.2/1/1		10	9.5	14hi	
	3	11220	1/3/.01		56	10.2	14hi	
	4	4913	1/10/0		68	9.9	6.4hi	
	5	5038	1/19/0		78	7.8	5.0hi	
SITDOWN	1	2013	.7/17/1		31	10.9		
LYNX	1	5675						
	2	1050						

Canopy Closure

TABLE 9. STREAM SUBSTRATE DATA- 1991.

STREAM	SEG-MENT	SAND %	GRAVEL %	COBBLE %	EMBEDDED-NESS %	GRAD-IENT
BIG SHEEP	1	28	56	16	5-25	1.5
	2	36	55	9	25-50	2.3
DEEP	1	20	28	50		1
	2	35	16	46		3.5
ONION	1					2.5
	2					12.0
ALDER	1	0	71	28	50-75	6.2
	2					
ORA-PA-KEN	1	60	25	12		2.2
	2					1.2
BLUE	1	27	41	32		2.8
	2	24	74	2		3.5
	3	38	44	18		5.5
21 MILE	1					3.0
	2					
23 MILE	1	0	54	46		8.7
	2					2.3
25 MILE	1					
	2					6.0
30 MILE	1					3.8
	2					1.0
	3					3.5
	4					3.4

NORTH NANAMKIN	1	2	18	42		2.0
	2	0	25	27		3.4
BRIDGE	1					2.7
	2	24	39	33		2.2
	3	4	62	32		3.8
	4	13	44	38		4.1
	5					3.2
IRON	1	36	56	8		5.0
	2	36	56	8		4.8
HALL	1	4	37	57	50-75	3.5
	2	3	18	79	50-75	3.0
	3	23	39	36	50-75	1.0
	4	12	22	63	50-75	1.0
	5	0	610	39		1.0
SITDOWN	1	10	37	51		3ave
LYNX	1	30	14	36		2.5
	12	Ill	113	47		112.0

TABLE 10. FISH POPULATION DATA (RAINBOW TROUT ONLY)- 1991.

STREAM	SEG-MENT	FISH/SQ. MTR POOL	FISH/SQ. MTR RIFFLE	FISH/100m	FISH/SQ.MTR OVERALL
BIG SHEEP	1	0.3	0	18	0.01
	2				
DEEP	1	2.77	0.06	23	0.06
	2				
ONION	1	1.3	0.3	491	0.52
	2			107	0.15
ALDER	1	0	0.1	32	0.06
	2				
ORA-PA-KEN	1				
	2				
BLUE	1	0.7	0.4		
	2	0.8	.01		
	3				
21 MILE	1	0.4	0.4	2.4	0.08
	2	0.4	0.4	7.0	0.02
23 MILE	1				
	2				
25 MILE	1				
	2				
30 MILE	1				
	2				
	3				
	4				

NORTH NANAMKIN	1	0.001	0		
	2	0.5	0.4		
BRIDGE	1	0.03	0.1	16	0.04
	2	0.03	0.33	20	0.06
	3	1.13	0.43	84	0.23
	4	0.22	0.03	17	0.05
	5				
IRON	1	0.04	0.05		
	2	0.1	0		
HALL	1	5.68	0.09	742	0.88
	2	0	0.01	22	0.03
	3	0.01	0.03	46	0.09
	4	0.19	0.02	20	0.04
	5				
SITDOWN	1	0.08	0.3	27	0.06
LYNX	1	0.06	0.04		
	2				

Big Sheew Creek

PHYSICAL DESCRIPTION

Big Sheep Creek is located in Northern Stevens County on the North Half of the former Colville Indian Reservation. It is a second order tributary to the Columbia River about 11 miles from the International border between the United States and Canada. Flows range from 11 c.f.s. to greater than 30 c.f.s. during spring runoff periods. Sheep Creek is utilized by a number of fish species including rainbow trout, kokanee, mountain whitefish, various sculpin and sucker species, and bull trout.

DISCUSSION

In 1991, 2,959 meters (Table 8) of stream were surveyed, beginning at the mouth and ending at the falls. The 80 foot Big Sheep Creek Falls forms a scenic but impassable barrier, which limits the amount of habitat available and reduces opportunities for adfluvial fisheries enhancement. Due to this factor Big Sheep Creek has a low priority for enhancement work for adfluvial rainbow trout compared to other streams. The area of suitable gravel is limited. Current Gold dredging operations have caused the destruction/relocation of some of the available spawning habitat (personal observation). Lower segment work could entail the installation of LWD in a very wide channel and floodplain. No Large Woody Debris (LWD) is noted in the data from the lower segment. The upper segment contains a considerable amount of LWD and rearing area, but is limited by the availability of suitable spawning gravels. Pool/riffle ratios are high in both segments (low number of pools). Enhancement work would need to include addition of suitable spawning gravels in both segments.

Big Sheep creek has a history of gold mining and several mining claims exist in the mid-reach area of this stream. The Washington Department of Natural Resources owns and manages the majority of the banks located in the mid reach. As a result, prospectors using dredges, pans and rocker boxes are commonly encountered along the creek. Many of the prospectors are operating without the proper permits, while most of those that claim to possess a hydraulics permit are also in violation of the 1987 Gold and Fish rules. Many of the areas that contain limited suitable spawning habitat are being destroyed or altered to a point where the gravel deposits are useless to spawning fish. The areas of altered habitat have been documented by photo and slides. Two old mine shafts exist that are connected to the stream substrate. In one upstream area, the remnants an old sluice box, carpet etc. can be seen.

Survey crews observed ample evidence of macro-invertebrate presence in this stream that includes mayflies, stoneflies, dragonflies, periwinkles (caddisflies), crayfish and bi-valve mussels.

MANAGEMENT RECOMMENDATIONS

Although Big Sheep Creek contains ample amounts of spawning gravel and rearing habitat, it will probably not be selected for enhancement efforts for the next phase of this project. Much of the existing habitat is being annually degraded by recreational placer mining. Current W.D.F.W. Gold and Fish rules allow year around panning. Sluicing and dredging are allowed during the months of June, July and August. Many of the miners do not have the proper Hydraulic Permit Application (HPA) permit for dredging/sluicing and as a result are unaware of the requirements necessary to sustain fish life. The annual dredging causes a redistribution of spawning gravels, creates holes along the streambank that changes the geomorphology of the streambed and alters the flow regime. Because of the gradient natural gravel deposits are found on the downstream side of large rocks and boulders. Mining activities relocate the available gravel to either all over the bed or to piles located out of the channel or along the bank.

MAP 4. BIG SHEEP CREEK AERIAL PHOTO.

Deep Creek

PHYSICAL DESCRIPTION

The mouth of Deep Creek is in Sec 20 of T40N, RNG40 E. on the upper Columbia River across from the mouth of Big Sheep Creek. It is located in northern Stevens County and is part of the "Old North Half" of the Colville Indian Reservation. It flows toward the west and drains a watershed area of approximately 359 square miles.

Existing substrate is very heavily silted in through out the surveyed area. In addition the substrate is coated with an unknown substance that resembles chalk. This unknown substance is deposited on the gravel making a non-slip surface. This substance may be some sort of clay coming from the natural breakdown of bedrock.

As is the case with the majority of upper reservoir streams, a falls exists that prevent adfluvial fish access to the upper reaches of the stream. In this case a series of slip face cascades and chutes limits access to all but the larger, stronger fish. Anecdotal information confirms the use/presence of adult adfluvial rainbow trout during spring periods above the series of chutes, slipface cascades.

DISCUSSION

Habitat enhancement/improvement opportunities are limited on this stream due to landowner considerations, substrate deposits, general lack of spawning habitat and the short distance to a series of falls. Deep Creek will not be chosen for enhancement efforts for Phase II and III. Landowners were reluctant to allow the interagency team access for the initial survey. It is apparent that considerable prejudice and distrust exists where Indian tribes are concerned.

TABLE 11. DEEP CREEK BIOLOGICAL PARAMETERS OF RAINBOW TROUT ELECTRO-SHOCKED.

SEGMENT	Condition Factor	Ave. Length (mm)	Ave. Weight (grams)
1	$1.107*^{10-6}$	148.7mm	145.2g
2	$2.217*^{10-6}$	86.1mm	15.7 g

MANAGEMENT RECOMMENDATIONS

Considering the condition of the substrate, the relatively short distance to the falls, and landowner considerations, Deep Creek should not be chosen for Phase II and III enhancement efforts.

<u>Onion Creek</u>

PHYSICAL DESCRIPTION

Onion Creek is a third order tributary flowing into to the upper Columbia River five (5) miles below the Town Of Northport. It enters the Columbia from the east side in Stevens Co. The habitat found in the lower reach has been channelized by grant from the U.S.D.A. during the late 1950's. The bank stabilization program was carried out for flood control. Habitat opportunities are limited due to the short distance to the 80 foot vertical falls.

DISCUSSION

Large scale, open pit mining, and the operation of a lead and zinc concentrate mill have had pronounced effects on the lower channel. In 1958, at the Van Stone Mine, a tailings dam blowout removed large areas of streambed and riparian vegetation and deposited tailings as far away as the Columbia River. At this time, large fish kills were documented by the Washington Department of Wildlife. Heavy metal and reagent contamination are certainly possible limiting factors.

Fish species encountered during electrofishing efforts include rainbow trout, bull trout, brook trout, and various sculpin and sucker species. A single, sexually mature, female kokanee was randomly electro-shocked out of riffle habitat during October of 1991. Substantial evidence of macro-invertebrate populations are present throughout the stream course surveyed.

TABLE 12. BIOLOGICAL PARAMETERS- ONION CREEK.

SEGMENT	CONDITION FACTOR	AVE. LENGTH (mm)	AVE. WEIGHT (grams)
SEG 1	$2.2*^{10-6}$	'78.3	14.6
SEG 2	$2.2*^{10-6}$	86.1	15.7

Onion Creek is also typical of upper reservoir streams having a major falls acting as a passage barrier. The picturesque 80 foot falls is located 6,725 meters from the mouth. The lower valley segment has been altered by past agriculture activities. During the 1950s because of the 1948 flood, extensive areas were rip-rapped with large boulders and logs to prevent bank overtopping and meandering. A fair quantity of spawning gravel exists in this lower reach, but the stream channel west of State Highway 25 is heavily silted in, Large woody debris is limited in this reach; the availability of small woody debris is also limited. The upper segment has a fair amount of habitat available for all life stages.

The land use here is primarily timber production followed by use for pasture and residential purposes. Intensive siltation is degrading habitat in the upland areas of Onion Creek. This effect is brought about by agricultural and mining practices

NANAGENENT RECOMMENDATION

Based on the aforementioned discussion, Onion Creek will not be selected at this time for enhancement efforts (Phase II and III). Current landowner attitudes (denial for access) and conditions (intensive silt deposition up stream from the mouth, west of Highway 25, and the high probability of heavy metal and reagent contamination) prevent enhancement efforts at the present time.

Alder Creek

PHYSICAL DESCRIPTION

Alder Creek is located on state and private lands in southern Stevens County. All upper areas have little to no riparian vegetation due to agricultural practices. Irrigation dams prevent upstream migration and cause areas of subsurface flow when impoundments are pumped dry in summer. The water resources of Alder Creek appear to have been over allocated.

DISCUSSION

Alder Creek is limited in its ability to provide adequate habitat for all life stages of fish namely rainbow trout. The lower segment is short, and has a limited amount of spawning substrate available. A series of small falls (10-20 feet each) prevent further upstream migration.

The upper segment has been extensively altered for agricultural use such as hay ground, pasture, and irrigation impoundments, as well as home sites and roads. As a result the upper segment is very heavily silted in.

MANAGEMENT RECOMENDATION

Alder Creek will not be selected for enhancement efforts due to the condition of the habitat in the downstream area available to adfluvial rainbow trout. A series of slip face cascades and chutes prevent migration into the upper valley segments where intensive agricultural operations have degraded the habitat.

Ora-Pa-Ken Creek

GENERAL DESCRIPTION

Ora-Pa-Ken Creek enters Lake Roosevelt approximately nine miles south of the Town of Fruitland. It enters Lake Roosevelt from the

west side and drains an area of approximately twelve square miles. Fish species composition was limited to rainbow and eastern brook trout in the upper reaches and the addition of a few sculpins in the lower reach. Spawning habitat is limited in the upland areas due to roads and agricultural development. The small fishery is maintained by natural production resident fish (this stream was historically stocked from hatcheries).
A very picturesque 12 foot falls separates the lower and upper segments. Rainbow trout are the dominant species below the falls with a mix of RBT and EBT found above. The dominant rainbow trout found are more than likely from adfluvial stock from Lake Roosevelt. Local residents have complained that military personnel annually caught substantial numbers of large rainbow trout spawners every spring.

DISCUSSION

Ora-Pa-Ken Creek will not be selected for future enhancement (Phase II and III). The lower valley segment is shorter than Alder Creek and contains a pair of 20 foot falls, the lower of which is very beautiful and secluded. These falls block migration to the upper area. The upper area has also been altered by landowner activities that include homesites and hay fields. Extensive areas of silt deposition are present due to the presence of a maintained dirt road, State Highway 25 and the proximity to barnyards and feedlots.

MANAGEMENT RECOMMENDATION

At this time enhancement efforts are not recommended for Ora-Pa-Ken Creek. The lower reach of the stream is somewhat short and contains a pair of picturesque falls that form barriers to upstream migration. The upper segment of 580 meters contains heavily sedimented substrate that is not conducive to rainbow trout reproduction. The fish species composition in the lower segment is limited to rainbow trout and sculpin while in the upper area, eastern brook trout is the dominant species. The primary use of the upper reach by eastern brook trout may be indicative of water quality, habitat conditions and easy access for the fishing public/hatchery stocking operations.

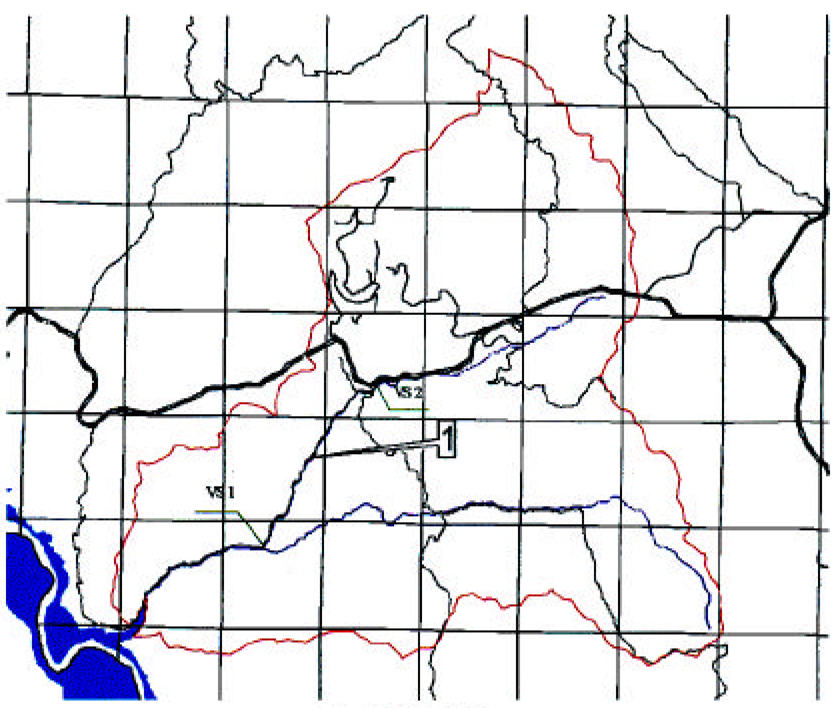
Blue Creek

GENERAL DESCRIPTION

Blue Creek is a second order tributary to the Spokane River arm of Lake Roosevelt. It is located in Stevens County on the Spokane Indian Reservation. It flows generally west and south. No wetted channel was encountered between Turtle Lake (30 acres) and Blue Creek. Flows are subsurface for some distance before upwelling into the channel. No direct (surface water) hydrological linkage is present between Turtle Lake and the existing channel. However, an old, dry channel exists that substantiates former flow episodes came directly out of the lake.

At the time of the survey the channel was dry, an indication that when spring freshet flows subside the streams runs sub-surface for a distance.

MAP 5. BLUE CREEK MAP.



Blue Creek Location Map

During 1991 a total of 9,389 meters of stream were surveyed beginning at the mouth and ending just below Turtle Lake where subsurface flows begin to change to surface flows. Substantial fish populations exist in the lower reaches of the stream; rainbow and eastern brook trout are the dominate species.

TABLE 13. BIOLOGICAL PARAMETERS- BLUE CREEK.

SEGMENT	CONDITION FACTOR	AVE. LENGTH(mm)	AVE. WEIGHT(g)
1	$1.5*^{10-6}$	1102.8	19.2
2	$1.3*^{10-6}$	98.3	13.2

DISCUSSION

This is the only stream surveyed on the Spokane Indian Reservation by the three cooperative agencies (Colville Confederated Tribes, Spokane Tribe of Indians and the Washington Department of Wildlife). The lower two reaches of Blue Creek have adequate areas of suitable spawning gravel available. Small passage barriers (beaver dams and debris jams) exist that can be easily removed using machines and/or by hand. Blue Creek is aptly named as the stream continuously carries a clay/silt load that taints the water blue.

MANAGEMENT RECOMMENDATION

Blue Creek will be selected for future enhancement efforts. Historical information from the Spokane Tribe and Eastern Washington University indicates substantial use by adfluvial rainbow Trout for spawning, and rearing activities. The Spokane tribe is a cooperator in this effort/project. The location on the Spokane Indian Reservation and current fisheries data conclude that this stream should be selected for habitat enhancement efforts. Efforts should be concentrated on providing shade to the streambed and installation of structures to allow better access to habitat in the upper reaches.

Twentv-one Mile Creek

GENERAL DESCRIPTION

21 mile Creek is located on the Colville Indian Reservation approximately ten miles below the Reservation/USFS boundary. It services a drainage of 40 square miles and enters the San Poil from the east. This small stream has potential for rainbow trout production, although the area of spawning/rearing is small. Excellent spawning gravel and cover are present in the lower valley segment. Upper area access may be limited by slip face cascade habitat in steep gradient. Access to the stream channel is variable by year due to the presence of a gravel bar and braided channel at the mouth. The lowest section (300-400 meters) of the channel goes dry in approximately 7 out of 10 years.

DISCUSSION

This small stream could provide some excellent habitat if not for the short distance of the drainage. Excellent spawning gravels exists that demonstrate use by adfluvial rainbow trout as well as eastern brook trout. The slip face cascade habitat between and in the upper reach restricts entry to all but large fish. The available habitat in the upper area is limited to juvenile rearing, then only if large adults could reach the upper gravel areas to spawn. Investigation (trapping) to determine adult fish use above the cascades is warranted, but will not be done at this time. This stream should be examined in the future for potential improvement/enhancement.

Twenty-three Mile Creek

PHYSICAL DESCRIPTION

Twenty-three Mile Creek (23 mile) enters the San Poil River from the east two miles south of 21 mile creek. The riparian area is well developed for the entire surveyed distance. In this perennial stream flows averaged 8 c.f.s. during summer low flow periods. Subsurface flows have been noted by area residents near the mouth on dryer years. Due to gradients exceeding 3.0%, the cascade habitat type is dominant in the lower segment. A series of small slip face cascades may be a migration barrier. The upper reaches (unsurveyed) of 23 mile creek provide a substantial rainbow and eastern brook trout fishery to Colville Tribal Members. Tribal Members use this area for recreational and subsistence fishing activities. Sculpin *(Cottus* spp.) and Dace *(Rhinichthys spp.)* are also found in the lower segment. Adfluvial rainbow trout access to the stream channel is may be hampered by the presence of a braided channel and gravel deposition that currently exists.

DISCUSSION

Enhancement opportunities are limited in 23 Mile Creek by the presence of the aforementioned extensive gravel bar and the resulting braided channel. The step pool cascade and slip face cascade habitat also limit habitat accessability and use. Note: most data has been lost for this stream since data collection.

MANAGEMENT RECOMMENDATIONS

Twenty Three mile Creek will not be chosen for enhancement work in the next phase of this project. The mouth of the creek has restricted entry due to the braided nature of the channel. The available spawning gravel is somewhat limited in the lower reach of the creek because of the step-pool cascade type habitat. This stream should be examined in the future for potential improvement/enhancement.

Twentv-five Mile Creek

GENERAL DESCRIPTION

Twenty-five (25 mile) Mile Creek enters the San Poil two miles south of 23 mile creek as a second order tributary. It flows in a westerly direction with a minimal contribution to the flow of the San Poil River. Two valley segments were surveyed in 1991. Segment one was mostly an undefined channel in an alluvial fan soil type made up of coarse broken, angular basalt and had little to no flow. The upper segment had some of the cleanest spawning gravels of the project streams. Electrofishing efforts conducted for population estimates confirmed that no fish were present.

DISCUSSION and MANAGEMENT RECOMMENDATIONS

Twenty-five Mile Creek should not be chosen for enhancement measures due to the lack of a defined mouth and substantial amount of dry channel/subsurface flows. The lower segment is totally subsurface for most of the year. The lower stream bed has damp areas indicative of past flow episodes. Former dry meanders and areas of braided channel are also present. The upper area contains some excellent gravels and rearing habitat, but access is blocked by the dry channel. A unimproved vehicle ford is present just below the segment break. The land in this reach is tribally owned and is dedicated to timber production. During the electrofishing survey no fish were found above the area blocked by subsurface flows. The survey area was limited to flowing water areas. Costs for the necessary re-channelization and meander construction would far out way any potential benefits.

Thirtv Mile Creek

PHYSICAL DESCRIPTION

Thirty Mile (30) Creek is located five miles south of 25 Mile Creek, draining an area of 24.9 square miles. It enters the San Poil from the east and is a perennial flowing stream. Several kilometers were surveyed with a single identified potential passage barrier. The potential barrier is an irrigation dam in the lower segment. Considerable numbers of rainbow and eastern brook trout were seen and enumerated during electrofishing surveys.

DISCUSSION and MANAGEMENT RECOMMENDATIONS

Thirty-mile Creek should not be chosen for enhancement work for the next phase. The lower area has a broken land owner base and has an irrigation pond that may block upstream migration. The upper reaches are heavily silted in due to past logging practices and the close proximity of a poorly maintained dirt road. The upper most segment has some excellent spawning/rearing habitat available, but it is above the blockage. This stream has the potential of becoming a major producer of adfluvial rainbow trout. This stream should be examined in the future for barrier removal and enhancement/improvements.

North Nanamkin Creek

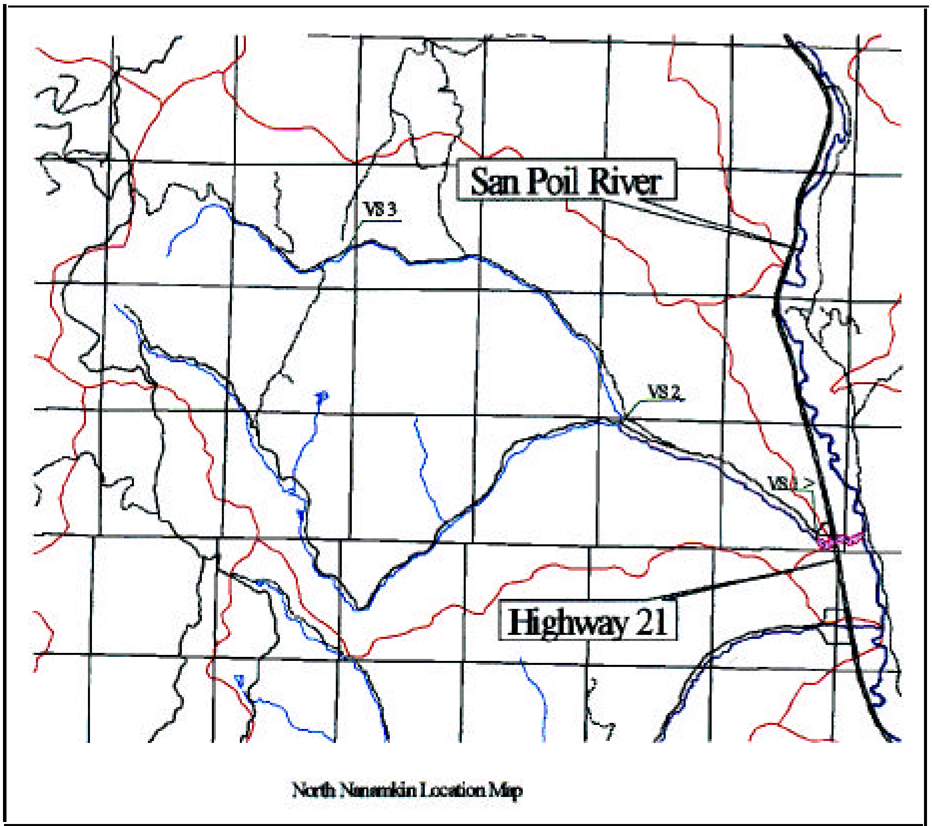
PHYSICAL DESCRIPTION

North Nanamkin Creek is **a** major third order tributary to the San Poil River. It is located on the Colville Indian Reservation several miles downstream from Westfork Creek. North Nanamkin enters the San Poil River from the west. North Nanamkin has a drainage area of 16 square miles. The pool/riffle ratio for segment 1 should be viewed with caution due to the low flow during habitat inventory. Adfluvial rainbow trout are the primary species present (>95%); an occasional occurrence of eastern brook trout and sculpin were found during data collection.

DISCUSSION

During the 1991 survey season a total of 15,421 meters were surveyed on North Nanamkin Creek. Areas of subsurface flow occur in the lower valley segment. This is due in part to the stream flowing across an alluvial soils that consist of coarse gravel and rock. The lower reach of this stream has had the riparian vegetation removed to allow for agriculture and livestock grazing considerations. Former channel meanders have been filled by past flood events. Fish access is possible during spring flow regimes, Interviews with fisheries personnel of the Colville Tribes Fish and Wildlife Department confirm the annual use of North Nanamkin creek by adfluvial rainbow trout for spawning activities. The Colville Tribal Fish and Wildlife Departments opinion is that habitat access and quality were factors limiting production, and thus the contribution to the Lake Roosevelt fishery.

In valley segment one, a pair of barriers exist. One is a perched culvert under State Highway 21. The second is the annual period of subsurface flow. Late summer subsurface flows postpone out-migration of young of the **year** (YOY) until late **fall** flow **periods** or spring freshets. At the boundary of the second and third segments a pair of perched culverts exist. One smaller secondary



MAP 6. NORTH NANAMKIN MAP AND AERIAL

culvert is in place for flow relief. Large adfluvial rainbow trout have been annually observed below this area during high flow periods. Backpack electrofishing surveys above the blocked area confirmed the absence of any fish.

MANAGEMENT RECOMENDATIONS

North Nanamkin Creek should be selected for enhancement efforts. The enhancements should include:

1. Restoration of meander habitat in the lower reach of the stream;
2. Log sill structures to create a series of steps for access to the culvert under State Highway 21;
3. In the upper reach **a** culvert must be reset and log sill structures added to allow upstream combined passage. This would include a holding pool on the lower side of the crossing;
4. The riparian corridor should be fenced to limit access by cattle;
5. Stream bank plantings of selected native plants to provide shade, long term recruitment of woody debris, and organic debris deposits to the channel that may aid in preventing subsurface flow episodes.

Bridge Creek

PHYSICAL DESCRIPTION

Bridge creek is a third order tributary to the San Poil River. It is located within the boundaries of the Colville Indian Reservation and drains an area of 30.4 square miles. It enters the San Poil River approximately 17 miles upstream from the mouth. Rainbow trout are the primary species present (>65%); numerous occurrences of eastern brook trout (especially in the upper segments) and sculpin were found during data collection.

DISCUSSION

Bridge Creek should not be chosen for enhancement work for the next phase. The mouth of the creek is undefined, flows across an alluvial fan that is a braided channel that contains beaver dams and heavy sediment deposits. The upstream landowner has done considerable channeling for flood control in the bottom segment, which has limited the habitat type to low gradient riffle. An artificial spawning channel could be created in the lower reach with some work. The cost of this work may prohibit any construction.

One potential passage barrier to migration exists. There is an undefined channel complicated by beaver near/at the mouth of the stream. Steep gradient and a rubble filled channel may have created a second potential barrier upstream in the third segment. The channel in the bedrock canyon segment is filled to a depth of 15 or more feet in places by the Ferry County Road maintenance crew as they clean out a ditch and dump the rubble over the hill(specia1 note: this problem has been resolved since the original surveys). The upper reaches contain significant amounts of suitable substrate and rearing cover. The cover is provided by large cobble and overhanging vegetation. The upper most segment is very steep which may be a barrier in itself. Future projects should consider Bridge Creek for enhancements as it is perennial and has considerable habitat in the upper reaches.

MANAGEMENT RECOMMENDATIONS

In the lower segments of Bridge Creek, below the steep walled canyon, substantial spawning and rearing habitat exists. Access to these habitats is somewhat limited due to the sediment deposition, braided channel, and the beaver dam complex found at the mouth. The riparian area near the mouth is well developed and offers considerable shade and potential recruitment of large woody debris. This project or another project may want to consider dredging the undefined mouth and channelization as necessary to allow adequate access by adfluvial rainbow trout or an alternative species of tribal/local interest, such as kokanee. An artificial spawning channel could be created here using water pumped from upstream areas. Several species of fish could potentially use the channel including rainbow trout, kokanee, bull trout and mountain whitefish. This stream should be examined in the future for barrier removal and enhancement/ improvements.

Iron Creek

PHYSICAL DESCRIPTION

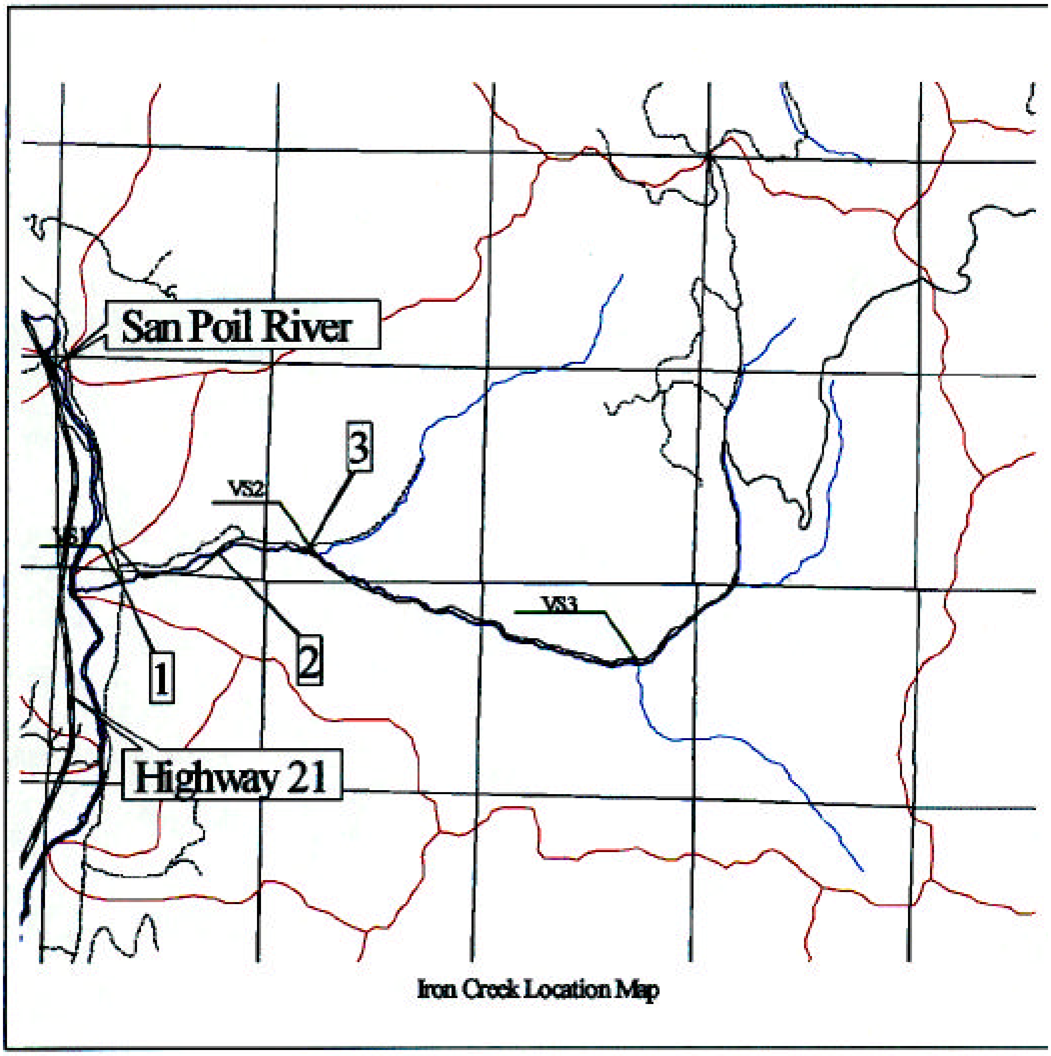
Iron creek is a third order tributary to the San Poil River entering from the east side of the drainage. It is located about halfway between Keller and the Bridge Creek Road to Inchelium. Iron Creek watershed is approximately 9.2 square miles in size. The mouth of the stream is well defined and offers easy access to adfluvial rainbow trout migrating from Lake Roosevelt. Three culverts are potential barriers (perched) and probably block fish migration.

DISCUSSION and MANAGEMENT RECOMMEDATIONS

Data analysis for Iron Creek revealed that a small amount of work would create access to substantial amounts of spawning/rearing habitat. Historically the stream held a substantial run of adfluvial rainbow trout that look similar to anadromous steelhead. Run size was believed to be declining (Jerry Marco, pers. comm., 1989) due to lack of access to sufficient habitat. The first segment goes dry in most years due to the glacial out-wash type soils, but access is unimpeded through this segment during the migration time of adfluvial rainbow trout. The watershed has an unimproved road that is adjacent to the stream most of the way to the top.

The enhancement work will probably entail the re-establishment of former meanders, removal and reinstallation of culverts and the addition of log sill structures to enable passage at above grade road culverts.

MAP 7. IRON CREEK MAP.



Hall Creek

PHYSICAL DESCRIPTION

Hall Creek is a major second order tributary to Lake Roosevelt. It directly enters Lake Roosevelt from the west bank and contributes a flow of 14 c.f.s. The mouth of Hall Creek is located just north of the Town of Inchelium, WA., and is the longest stream surveyed during this phase of the project. Hall Creek Watershed has an area of approximately 141.1 square miles on the Colville Indian Reservation and about 35 square miles north of the Reservation boundary. Two sub-watersheds of Hall Creek were in this project and analyzed as well (Sitdown and Lynx Creeks). Fish species found include rainbow and eastern brook trout, sculpins, and suckers.

DISCUSSION and MANAGEMENT RECOMMENDATIONS

Hall Creek should not be among the streams selected for enhancement work, even though it contains one of the larger flow regimes at an average of 14 c.f.s. and a length (longest surveyed) of 49,792 meters. Initial consideration was given to the removal of the series of steps, chutes and falls below the Town of Inchelium, WA. Tribal cultural beliefs hold that Coyote and the Creator made the falls and the membership will not allow the blasting/removal of such a feature. A short distance upstream from the Inchelium Highway and Hall Creek crossing a man-made falls exists that was formerly used as an irrigation diversion/power generation during historic mine/mill operations and precludes upstream migration. Data analysis and cultural considerations prevent further consideration. A limited amount of spawning and rearing habitat is present below the blocked area.

In the mid-upland areas, the habitat has been severely degraded by agricultural operations, livestock operations, riparian removal and timber harvest. Degradation consists of literally miles of silted in substrate. In some areas no riparian vegetation exists at all. Some of the riparian vegetation was removed for residential development and in other areas to facilitate an increased timber harvest base. Evidence of nutrient loading is present in the form of extensive blue-green and filamentous algae blooms. The close proximity of livestock feedlots and the application of commercial fertilizers has probably been responsible for this phenomena.

Land use for grazing and other agricultural activities has caused extensive silt deposition in all mid-reach areas. The remnants of a small wooden irrigation dam structure exists just downstream of the mouth of Lynx Creek and at times may prevent passage. Most of the upper areas are in good to excellent condition. Here the primary land use is timber production and secondarily as cattle pasture. Upper valley areas are used intensively by tribal members for camping, fishing, hunting and other recreational pursuits. Some natural fishery production takes place, however the fisheries are enhanced by Colville Tribal Hatchery operations.

Sitdown Creek

PHYSICAL DESCRIPTION

Sitdown Creek is a third order tributary to Hall Creek, draining an area of 22.6 square miles with an average flow of 3 c.f.s. Two thousand and thirteen (2,013) meters were surveyed during 1991. The majority of habitat type is low gradient riffle broken by small areas of rapid and step pool cascade. The large woody debris component was well established with 25 logs and 7 root wads in place in the wetted channel. Canopy closure was good at 40% average. This was provided by young, overhanging vegetation. Current land use practices are timber production, camping, recreational fishing, and livestock grazing.

DISCUSSION

Sitdown Creek should not be selected for enhancement opportunities because of the steep gradient, general lack of habitat and because it is a third order tributary of Hall Creek (adfluvial rainbow trout from Lake Roosevelt cannot get to this stream). Opportunities exist for enhancement in this particular stream, but not for the target species.

Lynx Creek

PHYSICAL DESCRIPTION

Lynx Creek is a third order tributary to Hall Creek, and is 36.4 square miles in size. The watershed is completely within the boundaries of the Colville Indian Reservation. Approximately 7 out of 10 years subsurface flows occur near the mouth at Seylor Valley Road.

DISCUSSION

Annual subsurface flow episodes occur in the lower valley segment that prevents upstream migration in the fall. This watershed is has tree cover much higher than historically and may be part or all of the reason for the subsurface flow pattern. The subsurface flows may also be partially caused by the absence of riparian vegetation near the mouth and adjacent areas (agricultural fields surround the bottom section). Areas in the upper segment, most notably above the Cecilia Smith and the Seylor homes, contain some of the finest habitat available. The area adjacent to "Moss Mollys Campground" is nearly pristine even though nearby timber harvest has occurred in the past

TABLE 14. BIOLOGICAL PARAMETERS- LYNX CREEK.

SEGMENT	CONDITION FACTOR	AVE. LENGTH(mm)	AVE. WEIGHT(g)
1	$2.2*^{10-6}$	78.3	14.6
2	$2.22*^{10-6}$	86.1	115.7

SUMMARY AND CONCLUSIONS

Data analysis allowed the selection of five streams for potential habitat enhancement. The selected streams and respective locations are Blue creek on the Spokane Indian Reservation, and North Nanamkin, South Nanamkin, Iron and Louie Creeks on the Colville Indian Reservation. These streams exhibited most of the characteristics outlined below.

1. Perennial flow- some streams exhibit 1 to 3 month periods of no flow for short sections (at the mouth) in late summer. This

does not affect the migration of the target fish, as they migrate in spring. The fish have not been observed spawning in these sections, therefore the affect to juveniles is probably minor.

2. Existing natural population of adfluvial rainbow trout. All five of the selected streams have these fish present.

3. Streams having historic use by adfluvial rainbow trout. All five of the selected streams have these fish present historically (established through local resident interviews and local biologists).

4. Existing potential for increased use by adfluvial rainbow trout. Stream habitat improvements to increase pool/riffle ratios, provide passage at existing barriers, and improve flow regimes would provide an increase of available habitat.

5. Streams with a high potential for successful restoration. All five streams may have variable potential for success depending upon the type of improvements. These will be determined in the next phase.

6. Habitat data analysis to determine cost effectiveness of proposed improvements. Data collection and analysis has been done on all the streams in this report. Preliminary analysis of the five selected streams show there is a good to excellent potential for success for effort, particularly with respect to removing passage barriers. Some of the effectiveness will be determined in the next two phases.

REFERENCES

Bisson, P.A., J.L. Nielson, R.A. Palmason, and L.E. Grove. 1982. *A System of Naming Habitat Types in Small Streams, with Examples of Habitat Utilization by Salmonids During Low Stream Flow.* In N.B. Armantrout (ed) Acuuisition and utilization of aquatic habitat information. Portland Oregon Conference 1981. Western Division, American Fisheries Society, 1982.

Carlander, K.D. 1950. *Some Considerations in the Use of Fish Growth data Based upon Scale Studies.* Trans America Fish Soc. 79:187-194.

Carlander, K.D. *1969. Handbook of Fresh Water Fishery Biology Vol.* 1. Iowa State University Press. Ames, Iowa.

Everhart, W.H. and W.D. Young. 1981. *Principles of Fishery Science 2nd Edition.* Cornell University Press. Ithaca, New York.

Hankin, D.G. and G.H. Reeves, 1988. *Sampling and Field Procedures for Visual Estimation of Habitat Areas.* USFS, Regional *Office,* Portland OR.

Hunter, Christopher J, 1990. Better Trout Habitat. *A Guide to Stream Restoration and Management.* Montana Land Reliance. Island Press. Washington D.C. Covelo, California.

Marco, G. 1989. Personal communication.

Nielsen, Larry A and David Johnson, *1985. Fishery Techniques.* Department of Fisheries and Wildlife Science Polytechnic Institute and State University.

Novotny, D.W. and G.R. Prigal *1974. Electrofishing Boats: Improved Designs and* Operation *Guidelines to Increase the Effectiveness of Boom Shockers.* Wisconsin Department of Natural Resources Technical Bulletin #73.

Platts, W.S., W.F. Megahan & G.W. Minshall. *1983. Methods for Evaluating* Stream, *Riparian and Biotic Conditions.* United States Forest Service General Technical Report INT-138, Washington, D.C.

Ralph, Stephen C. *1990. Ambient Monitoring Field Techniques Manual Version* 2.0. Center For Streamside Studies, AR-10 University of Washington Seattle, WA 98195.

Reichmuth, D. R. 1993. *Living With Fluvial Systems: An Introduction to River Mechanics.* Training manual supplied by Geomax P.C. and the U.S. Corps of Engineers.

Rosgen, D. and Fittante, B. L. 1986. *Fish Habitat Structures- a selection guide using stream classification.* In *Proceedings of the Northeastern* Trout *Stream Improvement Workshop.* Lock Haven, PA. August 11-14, 1986.

Rosgen, D. and Fittante, B. L. 1993. *Applied Fluvial Geomorphology.* Training manual supplied by Wildland Hydrology Consultants. Pagosa Springs, CO.

Scholz, A., K. O'Laughlin, D. Geist, J. Uehara, D. Peone, L. Fields, T. Kleist, I. Zozaya, T. Peone, & K. Teesattuskie. 1985. *Compilations of Information on* Salmon *and Steelhead* Total *Run Size, Catch, and Hydropower Related Losses in the Upper Columbia River Basin, above Grand Coulee Dam.* *Upper* Columbia United Tribes Fisheries Center, Fisheries Technical Report No. 2. EWU. Dept. of Biology, Cheney, WA.

Scholz, A.T., T. Peone, J.Griffith, S. Graves, and M. Thatcher. *1988. Lake Roosevelt Fisheries Monitoring Program, Annual Report.* Upper Columbia United Tribes Fisheries Center. Cheney, WA.

Scholz, A.T., T. Peone, J.Griffith, S. Graves, and M. Thatcher. *1989. Lake Roosevelt Fisheries* Monitoring *Program, Annual Report.* Upper Columbia United Tribes Fisheries Center. Cheney, WA.

Scholz, A.T., J.K. Uehara, J. Hisata and J. Marco 1986. *Feasibility Report on Restoration and Enhancement of Lake* Roosevelt *Fisheries* in Northwest Power Planning Council, Awwlications for Amendments. Vol. 3A: 1375-1489.

Wydoski, Richard S. and Richard R. Whitney. *1979. Inland Fishes* of Washington. University of Washington Press. Seattle and London.

APPENDICES

1. HORIZONTAL CONTROL SURVEY
2. STREAM CHANNEL SUBSTRATE
3. GRAVEL EMBEDDEDNESS
4. HABITAT DATA
5. BARRIERS
6. STREAM FLOWS
7. POPULATION ESTIMATES
8. BIOMASS AND DENSITY
9. AGE DETERMINATION, BACK CALCULATIONS, AND CONDITION FACTORS

INTRODUCTION TO METHODS

An initial survey was conducted to evaluate the quality and quantity of rainbow trout habitat in each selected tributary. This survey consisted of a comprehensive physical habitat assessment and population estimate. The purpose of conducting this survey was two fold. First to identify potential habitat improvements and second, to provide baseline data for later comparisons.

Each stream was inventoried during the summer low flow period to collect data on biological and hydrological conditions. The physical habitat survey involved stream flow measurements, habitat unit classification and habitat unit measurement. Riparian conditions were assessed along with substrate condition. All obstructions were noted especially those that form certain habitat types (pools),or migration barriers. Survey methods were developed using Timber/Fish/Wildlife (TFW) stream ambient monitoring program methodology described by Ralph (1990). These methods have proved to be reliable and effective for inventory of habitat conditions.

The habitat inventory was completed in three stages, **(1)** horizontal control; (2) physical habitat data collection; and (3) population estimate and densities.

1. Horizontal Control Survey

Essential to the success of the monitoring project is a method to relocate sampled segments within the stream, so that they may be resampled in subsequent years. This was done by establishing control points along the survey path. The following describes a method for measuring horizontal distance between upstream and downstream points along the bank following the general course of the stream channel. In this way a longitudinal profile of the stream can be developed and key features noted, and the surveyed segments can be relocated in future years.

Field work began by delineating streams into their component valley segments based upon recognizable combinations of key attributes. Stream segments delineated by use of this diagnostic tool allow for an understanding of the processes that slope the character of the stream and thus its in channel habitat. In the field, valley segments were further broken down into strata which were marked by control points (aluminum tags) placed at appropriate intervals along our survey path.

As the survey team progresses upstream a line of sight was picked along the stream course. One team member walks upstream as far as possible without leaving the other team members line of sight. When the point was reached where it will become necessary to go out of sight the upstream member stops and places a numbered aluminum tag on a tree or stake using an aluminum nail (The date and tribal affiliation number are scribed on the numbered tag). With a team member at each reference (turning) point the distance was measured with the hip chain or Sonin device and that reading recorded on the data sheet. At this point a compass was used to determine the bearing in degrees of the upper point with reference to the lower point. This data was also recorded. Using a clinometer the gradient is gauged at every sixth turning point. The bank-full width and depth are also recorded at this time. Bankfull width and depth are measurements taken between the respective bank high water marks. An imaginary line was drawn between these marks and a depth was gauged from the stream bottom to the line using a telescoping rod. In this manner progress was made while placing sequentially marked tags at each turning point going upstream until the stream course end was reached. Later, within the distance between each turning point the individual habitat units (riffles, pools and cascades) were identified and measured.

2. Stream Channel Substrate

This important physical component was accounted for by conducting a pebble count (Wolman, 1954) at six selected riffle units per valley segment during the Horizontal Control Survey. The pebble count will yield information about coarse particle size distribution within selected riffles that is more reliable and easily analyzed. The bed material that characterizes the channel bottom was an important determinant of fish spawning and wintering quality. This method was designed for coarse sized particles and is therefore bias against very small and very large particles.

Classification of Stream Bedload (Substrate) by Particle Size

Particle Diameter Size	Sediment	Code
>50 inches (128 cm)	boulder	10
25 - 50 inches (64 - 128cm)	large Cobble	9
12 - 25 inches (32 - 64 cm)	medium cobble	8
6 - 12 inches (16 - 3.2 cm)	small cobble	7
3 - 6 inches (8 - 16 cm)	coarse gravel	6
1.6 - 3 inches (8 - 16 cm)	medium gravel	5
0.8 - 1.6 inches (4 - 8 cm)	small gravel	4
0.4 - 0.8 inches (2 - 4 cm)	pea gravel	3
0.2 - 0.4 inches (0.5 - 1 cm)	coarse sand	2
0.1 - 0.2 inches (0.25 - 0.5 cm)	medium sand	1
0.05 - 0.1 inches (0.125 - 0.25 cm)	fine sand	0

Boulders are stratified into two size classes.

Cobble stabilizes the stream bottom, provides habitat for fish rearing, and is the substrate where much of the food for fish is produced. Cobble is divided into three size classes.

Gravel is important for spawning, incubation of embryos, and as substrate for some aquatic invertebrates. Gravel is distributed among four particle sizes.

Sand (fines) Fine sediment is separated into three classes consisting of sand. (coarse, medium and fine sediment). The reason for the separation is that the larger particle can trap alevins in the redds, and the small fine particles decrease water flow through spawning gravels.

Classification of stream bedload (substrate) by particle size shows the codes used. The pebble count procedure involves selecting 100 substrate particles within a riffle, measuring their intermediate axis diameter size and recording it in a corresponding size category. The procedure was to randomly wander over the entire width of the channel encompassing the unit, and at every second step reach down without looking and place your index finger on the particle directly beneath the toe of your boot. The particle is removed and the middle axis (Dt) is measured with a metric ruler.

3. Gravel Embeddedness

In streams with a large amount of fine sediment, the coarser particles tend to become surrounded or partially buried by the fine sediment. Embeddedness quantitatively measures the extent to which larger particles are embedded or buried by fine sediment. An etnbeddedness rating should allow for some qualitative evaluation of the channel substrate suitability for spawning, egg incubation, and habitats for aquatic invertebrates, and young over wintering fish (Munther and Frank, 1986; Burns and Edwards, 1987; Torquemada and Platts, 1988; Potyondy, 1988). The rearing quality of the instream cover provided by the substrate can be evaluated also. As the percent of embeddedness increases, the biotic productivity is also thought to decrease.

The basic procedure for measuring embeddedness is to select a particle, remove it from the stream bed while retaining its spatial orientation, and then measure both its total height (Dt) and embedded height (De) perpendicular to the stream bed surface. Percent embeddedness is calculated for each particle until at least 100 particles are measured. Individual embeddedness values are averaged to yield a mean embeddedness value. This procedure is repeated six times per valley segment. The individual values of (Dt) and (De) from each valley segment are summed, and a percent cobble embeddedness (PCE) for each valley segment is calculated from the formula.

$$PCE = De / Dt$$

This estimate of embeddedness was done at active spawning areas (riffles, pool tail crests) selected by the characterization of the bed material. To enhance one's judgement in making this rating, remove a particle of bed material and try to estimate as a percent of how much of the vertical dimension of the particle was embedded by sand or silt. Usually, a distinct line can be seen on the surface where the portion not embedded was exposed to flowing water. Classification of the percent of embeddedness is done according to the rating.

4. Habitat Data

A comprehensive survey is conducted on the habitat in order to provide a complete and accurate account of the quality and quantity of physical habitat available to rainbow trout. The survey begins at the mouth of the stream or its confluence with a mainstem stream at the first turning point of the stream. Initially the habitat unit is selected by type and recorded as required in ambient monitoring handbook (Ralph, 1990). Once the habitat is identified measurements of habitat length, average width and deepest depth to the nearest 0.1 feet are taken. Classification and number of rootwads and woody debris are recorded according to their location within the stream. Classification of seral stage vegetation type, and land use on the left and right bank of the measured habitat unit is recorded again according to habitat units codes derived from TFW 's Ambient Monitoring Method. Canopy closure by percent is taken using a densiometer at every fifth habitat unit. Length of bank cutting and mass wasting is measured and recorded. Bottom substrate is measured ocularly at six sites per valley segment.

5. Barriers

Barriers or obstructions to upstream passage were noted and recorded. Each barrier is classified as to type and location within the stream channel. Barriers commonly encountered are debris jams, beaver dams, natural falls, log and rock jams, man-made structures such as irrigation dams and **road** culverts and high stream velocity caused by high gradient terrain.

6. **Stream Flows**

Stream flow measurements were taken at the rate of one (1) per valley segment on each stream. A pygmy flow meter was used at each study site. Sites were selected simply by being easily accessible with a minimum of brush or other interfering debris present. At each selected site the telescoping rod was placed across the stream to determine stream width. The stream was then divided into a minimum of ten (10) transects and the metering device used to count, (audio or visual) the number of revolutions. Flow rates for each transect were developed using

calculations for the number of revolutions and time in seconds multiplied by the area of each transect. The resulting figures of each transect were added which provides the total flow at each site. At each site two (2) flow measurements were taken in close proximity and the results averaged to account for any error in counting due to the potential for improper placement of the pygmy device.
The total discharge or flow calculation was based on the sum of the flows for individual transect sections as follows:

$$Q = \frac{(V \times W \times D)}{N}$$

Where: V = Velocity
D = Depth
w = Width
N = Number of cells

The flow for each transect section is calculated and then summed to get the total discharge. The number of sections used in any flow measurement depends on the variability of velocities within the channel. Usually, at least 15-20 measurement points should be used unless the channel is extremely regular in both bottom elevation and velocity distribution. Measurement points should be taken at all breaks in the gradient of the stream bottom and where any obvious changes in flow velocity occur within the channel. It is advisable to space the transect sections so that no partial section has more than 10 percent of the total flow contained in it. Cells of equal width across the entire section are not recommended unless the channel cross section is extremely uniform.

7. Population Estimates

Rainbow trout populations were estimated in all five streams in September and October 1990 utilizing the two pass methodology of Seber-LeCren to establish population densities of rainbow trout. September and October offer a time period when population estimates are more accurate due to low flow conditions and because fish hatched in the previous winter and spring are up out of the gravels and have reached a size that the dip nets are able to retain.

Population estimates were conducted on ten percent (10%) of each habitat type found within a given valley segment. Habitat units were divided into three categories (cascades, riffles, pools) as described by Ralph (1990). The unit pool was further separated into scour pools, plunge pools, eddy pools or scour holes. The lengths of each pool unit type, or riffle were recorded and a total was determined and fish population estimates were sampled on 10% of the total distances recorded. The same calculations were used for riffles and cascade categories.

After the ten percent figures were calculated for each valley segment, sites were chosen at random for electro-shocking surveys. Ease of access was an important criteria because of the difficulty encountered carrying the electro shocker over rough terrain and through heavy brush.

A Smith-Root model VII backpack electro-fisher was used to stun fish which were then collected with dip nets. Voltage output, pulse width and frequency were adjusted to deliver 0.3 to 0.5 amperes of current into the water. Electra-fishing parameters were: Voltage output = 400 volts; output current = 0.4 to 0.5 amps, pulse width = 8 ms, and pulse frequency = 60 Hz. Stream temperatures were measured with a hand held thermometer.

In practice, an area of a particular habitat type is selected. The length and average width are determined to provide data for biomass calculations. Block nets are then placed at the downstream and upstream ends of the unit being sampled. At this point one crew member enters the creek with the shocker flanked by two crew members carrying dip nets. As the fish are stunned they are carefully placed in five gallon plastic buckets where they quickly revive. The complete length of the netted unit is covered on the first pass by the shocker. After the first pass is completed the fish held in buckets are weighed and measured with a creel board. Fish scales are then removed for later age determination on a micro fiche reader. The fish from the first pass are then held in a bucket until after the completion of the second pass. After fish have been weighed, lengths recorded and scale samples removed they are all returned to the stream unharmed.

If the number of fish taken at the completion of the second pass, is more than fifty percent of the first pass, a third and fourth pass is required or until the even numbered passes are less than fifty percent of your previous pass. The crew then removes the block nets allowing the natural recruitment process to move fish back into the test site. Another site is selected and the crew moves upstream.

All fish were captured using standard guidelines and procedures outlined by Novotny and Priegel (1971, 1973) and Reynolds (1983).

After all data is collected a population estimate was calculated using the following Seber LeCren formula.

Where: N = estimated population size

U_1 = # of fish captured on first pass

U_2 = # of fish captured on second pass

T = total # of fish collected

Seber-LeCren formula: $$N = \frac{(U_1)^2}{U^1 - U_2}$$

After calculating the population estimate the accuracy was determined by calculating the standard error using the following formula.

Standard Error (S.E.) = $$N = \frac{(U_1)^2 \times (U_2) \times T}{(U^1 - U^2)}$$

After the standard error was determined, a ninety-five percent confidence interval (CI) was placed around the estimate. This was done by multiplying the standard error (S.E.) by a factor of 1.95 (S.E. x 1.95). This means that there was a five percent chance that the population estimate fell outside the range represented by N±.

8. Biomass and Density

Rainbow trout biomass was calculated using data collected during the habitat phase and population estimate. The total area in square meters for each stream was calculated, as well as for the habitat unit categories of pool, riffle and cascades.

Let M^2 = total area of stream in square meters
W = average weight
P = population estimate
B = biomass

W x P = total biomass
then B / m^2 **= biomass** per square meter
Recorded weights were averaged and multiplied by the population estimate to obtain a total biomass figure for each habitat unit type and for the entire stream. Further calculations were required to obtain the biomass per square meter.

9. Age Determination, Back Calculations, and Conditions Factors

In the field, scales were taken from appropriate locations for each species as described by Jerald (1983) and placed in coin envelopes labeled with fish number, length, weight, location, date and species for later analysis. In the laboratory, back calculation measurements and age class of each fish were determined simultaneously. To obtain the data, scales were removed from the envelope and placed between two microscope slides. The slides were then placed in **a** Realist Vantage 5, Model 3315 microfiche reader. the scale image was then projected onto the screen and a non-regenerated, uniform scale was selected to determine age and back calculation using the following procedures:

1. Age was determined by counting the number of annuli (Jerald, 1983)
2. Back calculation measurements were determined using a T-square metric ruler.
    a. Scale length was determined by placing the 0 mm mark at the center of the focus with the T perpendicular to the longitudinal axis of the scale.

b. Annulus distance was then measured from the same origin to the last circuli of each annulus with the T square in the same position.
Each measurement was made under constant magnification to the nearest millimeter.